HABITATS, MOVEMENTS, AND FOODS OF RIVER OTTERS IN COASTAL SOUTHEASTERN ALASKA

A
THESIS

MASTER OF SCIENCE

Douglas Niels Larsen, B.S.
Fairbanks, Alaska

December 1983

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IN COASTAL SOUTHEASTERN ALASKA

A THESIS

Presented to the Faculty of the University of Alaska
in Partial Fulfillment of the Requirements
for the Degree of

MASTER OF SCIENCE

By

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ABSTRACT

Habitat use, movement patterns, population characteristics, and feeding habits of river otters inhabiting Cholmondeley Sound in southeastern Alaska were studied from June-August 1980 and all of 1981. Otters avoided clearcut habitat but used old growth, 60-70 year old second growth, residual beach fringe, and island habitats in proportion to availability. Use of terrestrial habitat was usually restricted to a <20 m fringe of timber adjacent to convex shorelines with short intertidal lengths consisting predominantly of bedrock. Otter burrows were within 0.9-22.9 m of beaches and were usually in cavities under trees and/or snags. Otter travel routes generally paralleled the shore-line. Home ranges overlapped and varied for radio-tagged otters from 8.9 km^2 to 24.8 km^2. Population size was estimated as 86-95 otters in 1981; a density of 1 otter/1.9-2.1 km of shoreline. Fish occurred in 96% of 272 scats. Fish from the Cottidae, Scorpaenidae, and Hexagrammidae were the most commonly consumed.

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ACKNOWLEDGEMENTS

Funding for this study was provided by the U.S. Forest Service and logistic support was provided by the Ketchikan offices of the Alaska Department of Fish and Game and the U.S. Forest Service, Tongass National Forest. I am grateful to Paul Harrington, U.S. Forest Service, Idaho, for his role in initiating the study and to Glen Cantreras and Bryce Rickel, U.S. Forest Service, Ketchikan, for their assistance with logistics, equipment, and finances. I thank Robert Wood, Alaska Department of Fish and Game, Ketchikan, for his assistance with logistics and field work and for his constructive comments and suggestions.

A special thanks is extended to Dr. Philip Gipson, my advisory committee chairman, for his guidance, encouragement, inspiration, and frankness. I thank Dr. Frederick Dean for his advice and critical review of this thesis. I am grateful to Drs. Samuel Harbo and Edward Murphy for their consultation on analytical and statistical methods. I also thank Dr. Harbo for his critical review of the thesis. I would like to thank Dr. Winifred Kessler, University of Idaho, for her suggestions concerning sampling techniques.

Several individuals provided assistance with field work and/or other tasks during the study. I would like to thank Charles (Rick) Johnson for his companionship throughout the 15 months we spent together in Cholmondeley Sound and for assisting with many phases of the otter study. I thank Susan Cooper and Per Stadigh for their assistance with field work; Vern Starks, DVM, for surgically implanting radio-transmitters in captured otters; and Kathy Lucich and Walt Matell for their friendship and for sending my mail to me while I was in the field. I am also grateful to the several airplane pilots who provided safe and reliable transportation. The help provided by secretaries Norma Mosso and Tina Picolo is appreciated as is the skillful assistance provided by the IAB secretaries and graphic specialist, Don Borchert, who prepared the figures in this thesis.

I am grateful to Norm, Harriet, Ron, and Virginia Olson and Mike and Margaret Gallatin for their friendship and kindness during my stay in Cholmondeley Sound. The information concerning river otters which Norm, Ron, and Mike provided was valuable and is greatly appreciated.

I am forever grateful to my parents for their encouragement, support, and ambitions on my behalf. To the faculty and fellow graduate students of the Wildlife Department, University of Alaska, I extend a sincere thanks for the many enlightening discussions, friendship, and good-natured kidding.

INTRODUCTION

River otters (*Lutra canadensis*) occur throughout most of North America. These amphibious mustelids are distributed throughout Alaska except on the Aleutian Islands, Bering Sea Islands, and arctic coastal plain (Hall 1981). River otters resemble large weasels with long slender bodies and short legs. The neck and shoulders are thick and well muscled, the feet are webbed, and the tail is long, tapered, and muscular. The head is broad with small ears, prominent eyes, and a short wide muzzle. Pelage color varies from brown to almost black with the chin, throat, cheeks, and chest usually lighter, varying from brown to almost beige (Deems and Pursley 1983). Adults weigh 7 to 16 kg and are 101 to 152 cm in length. Males are generally about 25% larger than females (Solf 1978).

River otters are chiefly nocturnal although they are frequently active during the daylight hours. They are excellent swimmers and are associated with fresh, brackish, and/or salt water. Otters are social animals and are often observed in groups. Their diet consists primarily of fish. In coastal areas of Alaska, river otters usually restrict their use of terrestrial habitat to a <20 m-wide fringe of forest adjacent to the coast. Occasionally they travel overland for considerable distances.

River otters breed in late spring. The zygote develops to the blastocyst stage and remains dormant in the uterus until early the following spring. After implantation, the embryo develops rapidly. Females give birth to one litter a year. Litters usually consist of two or three pups. In southeastern Alaska parturition probably occurs during May (Woolington, in prep.).

Roughly 2000-3000 river otters are trapped and/or shot in Alaska each year; most are taken from southeastern Alaska, southcentral coastal Alaska, and the Yukon-Kuskokwim Delta (Rearden 1981). In most recent years the average pelt price has been between $30 and $60, however, during the 1978-79 trapping season the average price went up to $84 per pelt (Anon. 1980). The total annual value of river otter pelts in Alaska varied from $103,224 in 1980-81 to $61,504 in 1982-83 (H. Melchior, pers. commun.). Recreational values associated with otter trapping in Alaska have not been quantified, but it is apparent that otter trapping is an important form of winter recreation for many Alaskans.

Little is known about the ecology of wild, free-ranging river otters in North America. Prior to this study, no quantitative studies treating ecological aspects of river otters had been conducted in Alaska. Home (1977) presented information based on observations he made of a population of otters in Glacier Bay, Alaska; however, he did not tag individual otters. A large amount of lore concerning river otters passes among Alaskan trappers, but this information varies in value and reliability and has not been compiled or published.

In southeastern Alaska, clearcut-logging is the major cause of habitat alterations. Impacts of logging on otter habitats and use of habitats by otters were previously not known. This has made it difficult for wildlife biologists and timber managers to predict the value of a piece of land as otter habitat, or to make predictions about effects of logging on otter habitat.

Until 1954, the harvest of timber on the Tongass National Forest in southeastern Alaska was small and primarily for local consumption (Rogers and Hart 1978). In 1954, a mill producing 272 metric tons daily (later increased to 476 metric tons) of pulp went into operation at Ketchikan. The average annual cut on the Tongass National Forest jumped from 55 million board feet for the period 1949-1953 to 202 million board feet for the period 1954-1959 (one board foot is equal to approximately 2360 cm^3). Timber harvest increased to a high of 554 million board feet during the period 1970-1974 (Rogers and Hart 1978). Through the Alaska National Interest Lands Conservation Act of 1980, the U.S. Forest Service became congressionally mandated to provide an average of 450 million board feet of timber to the logging industry each year for 10 years. In addition, 250 million board feet of timber are expected to be cut annually on state and native land, making the estimated annual harvest 700 million board feet of old growth timber. Harvesting old growth forests at such a rate has far-reaching implications for wildlife.

The present study was initiated in 1980 to collect data related to several aspects of river otter ecology and to assess the impacts of logging upon these coastal mustelids. Information reported in this thesis was collected during June - August 1980 and all of 1981.

Specific objectives of the study were:

1. To determine use by river otters of old growth timber stands and second growth stands of various successional stages;
2. To determine daily and seasonal movement patterns and home ranges of river otters; and
3. To determine principal prey species eaten by river otters.

STUDY AREA

The study was conducted in Cholmondeley Sound (pronounced "Chomly"), located 32 km southwest of Ketchikan on the east side of Prince of Wales Island (Fig. 1). Cholmondeley Sound encompasses approximately 87 km^2 and is largely protected from strong wave action. Most of the study was conducted between Dora Bay and Chasina Point with only limited efforts in the west and south arms (Fig. 1). The field camp, located in Lancaster Cove (Fig. 1), consisted of two well-equipped cabins belonging to the U.S. Forest Service.

The topography of the area is typical of fjord-like landscapes formed by glaciers during the Pleistocene epoch with carved out bays, mountain valleys, and associated water drainages. Relief is relatively subdued around Cholmondeley Sound where most of the terrain rises from sea level to 600 m with only a few isolated mountains rising between 900 and 1000 m. Freshwater lakes in the area vary in size from approximately two to 65 ha and in type from coastal marshes to alpine cirque lakes. Many lakes contain Dolly Varden char (*Salvelinus malma*) and coastal cutthroat trout (*Salmo clarki clarki*). Several freshwater streams occur on the study area, some of which are used as spawning and rearing habitat by salmonid species.

The intertidal zone (area between high and low tides) varies from short, steep bedrock to long, gently sloping boulder, sand, and mud beaches. Tide level fluctuates from highs of approximately +6.0 m to lows of −1.5 m. Beach substrate consists predominantly of gneisses and schists, much of which is covered with brown and/or green algae. The

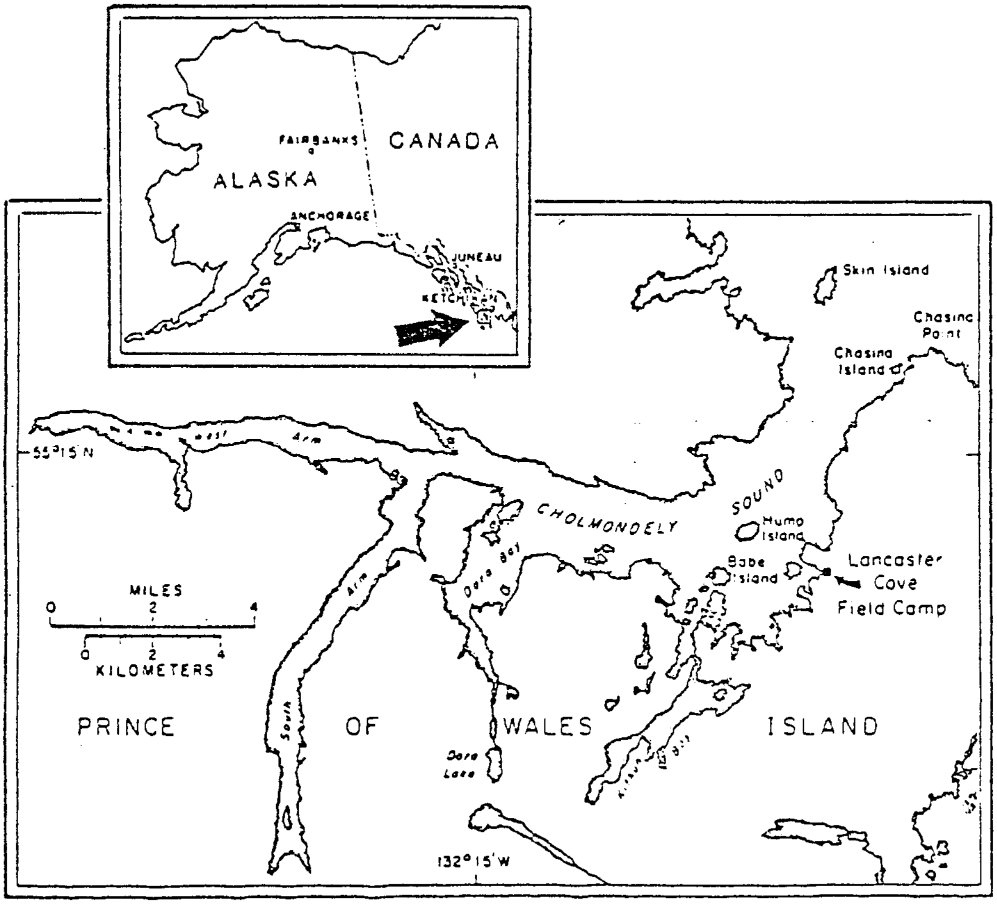

Fig. 1. Cholmondeley Sound study area. Most field work was conducted between Dora Bay and Chasina Point, 1980-1981.

shoreline is convoluted and includes points, straight sections, and bights. Several islands and reefs occur throughout the area.

Terrestrial vegetation begins within 1-2 m of the high tide level. Trees in the coastal forest consist primarily of western hemlock (*Tsuga heterophylla*), Sitka spruce (*Picea sitchensis*), western red cedar (*Thuja plicata*), and Alaska yellow cedar (*Chamaecyparis nootkatensis*), all of which grow on natural mineral soils (Spodosols). Mountain hemlock (*Tsuga mertensiana*) and lodgepole pine (*Pinus contorta*) occur in poorly drained habitats and at higher elevations where extensive areas of organic soils (Histosols) are found. Red alder (*Alnus rubra*) and Sitka alder (*A. sinuata*) are pioneer species which occur in riparian habitats, along beaches, and in clearings. They often form dense thickets on logged areas.

Blueberries, huckleberry (*Vaccinium* spp.), salal (*Gaultheria shallon*), rusty menziesia (*Menziesia ferruginea*), and devilsclub (*Oplopanax horridum*) are the principal shrubs occurring in the forest habitat below timerline. Gooseberries and currents (*Ribes* spp.) and salmonberries and thimbleberries (*Rubus* spp.) occur in forest clearings and along streams. In recently clearcut areas these shrubs form dense thickets.

A maritime climate dominates the area because of the proximity of Pacific Ocean waters. Normal temperatures range from 9 to 18 C in summer and from -2 to 5 C in winter (Appendix A). Annual precipitation is normally about 2.9 m, most of which is in the form of rain (Appendix B). Winds blow predominantly out of the south-southeast at an average annual velocity of 17 km/hr with peak gusts reaching as high as 96 km/hr (Appendix C).

Although storms and moderate to heavy precipitation occur on the study area throughout the year, storms are most frequent and precipitation is heaviest from September through November. In winter, snow may fall frequently throughout the region; but at lower elevations it usually melts within a few days.

Several indigenous wildlife species and a few introduced species occur on Prince of Wales Island; most occur in the Cholmondeley Sound study area. Black bears (*Ursus americanus*) moved northwestward from a southern refugium following the late-Wisconsin ice recession and became established on Prince of Wales Island and on other islands in the southern half of the Alexander Archipelago. Brown bears (*U. arctos*), on the other hand, moved south from a northern refugium and established themselves on Admiralty, Baranof, and Chichagof Islands in the northern region of the archipelago (Klein 1965). These two species do not coexist on any of the islands in southeastern Alaska.

The timber wolf (*Canis lupus*) probably followed the Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) into coastal southeastern Alaska and penetrated to those deer-occupied islands to which they were capable of swimming (Klein 1965). Both species presently inhabit Prince of Wales Island.

Pine marten (*Martes americana*) are not indigenous to Prince of Wales Island. However, the Alaska Game Commission released 10 marten on the island in 1934 and a viable population now exists. Raccoons (*Procyon lotor*) were introduced on Prince of Wales Island during the

1930's by fur farmers (Manville and Young 1965). Although uncommon, they are still present on the island. Mink (*Mustela vison*) and river otters are indigenous to the island (Burris and McKnight 1973). Sea otters (*Enhydra lutris*) are re-established on the west side of Prince of Wales Island as a result of transplant efforts by the Alaska Department of Fish and Game between 1965 and 1969 (Schneider 1973). Rarely do sea otters venture into the inside waters of the Alexander Archipelago and movements into the Cholmondeley Sound study area have not been reported.

Beaver (*Castor canadensis*) are indigenous to Prince of Wales Island and inhabit several of the freshwater lakes on the study area. On occasion, beavers in transit between adjacent freshwater systems can be seen swimming along the marine coast. Other rodents include the deer mouse (*Peromyscus maniculatus*), long-tailed vole (*Microtus longicaudus*), and northern flying squirrel (*Glaucomys sabrinus*). The dusky shrew (*Sorex obscurus*) is the only insectivore which occurs on the island (Manville and Young 1965).

Harbor seals (*Phoca vitulina*) occur in relatively large numbers in Cholmondeley Sound along with a few northern sea lions (*Eumetopias jubata*) and Pacific white-sided dolphins (*Lagenorhynchus obliquidens*). Hump-backed (*Megaptera novaeangliae*), grampus (*Grampus griseus*), and killer whales (*Orcinus orca*) occasionally venture into Cholmondeley for brief feeding forays during their movements through the inside passage.

Bald eagles (*Haliaeetus leucocephalus*) are commonly seen along the coast of the study area where they nest in mature spruce trees. In the fall, eagles can be seen in concentrations of up to 20 or 30 individuals in the vicinity of freshwater streams where they scavenge carcasses of spawned pink salmon (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta*). Several passerine species make use of the old-growth habitats where well-developed tree and shrub layers provide structural complexity and suitable feeding and nesting substrate (Kessler 1979).

Waterfowl are abundant throughout the area during migration between northern nesting and southern wintering areas. Some, such as Vancouver Canada geese (*Branta canadensis fulva*), make use of freshwater ponds and shallow lakes on the study area for feeding, nesting, and brood-rearing. Large numbers of alcids, including the common murre (*Uria aalge*), pigeon guillemot (*Cepphus columba*), and murrelets (*Brachyramphus* spp.), occur on the study area during the summer months.

Many fish taxa occur in Cholmondeley Sound, the most abundant of which are the cottids which are found in shallow and moderately deep water of the intertidal zone, with several species of cottids well established in freshwater. Quast and Hall (1972) list the major fishes of the Cholmondeley Sound area.

Historically, Cholmondeley Sound was inhabited by tribes of Tlingit Indians (Rogers 1960). These Indians were apparently the sole occupants of most of southeastern Alaska until sometime during the early 1800's when members of the Haida Indian tribe moved northward from a colony located on the southern tip of Prince of Wales Island and became established in the Ketchikan area; Haidas inhabited the old village of Kasaan in 1839, located in Skowl Arm, approximately 20 km north of Cholmondeley Sound (Rogers and Hart 1978). Populations of Tlingits were last reported in the Ketchikan area in 1839 and it is assumed that the Haidas became sole occupants of this region until 1887 when Tsimpshian

Indians migrated from British Columbia to Annette Island and founded Metlakatla, located approximately 35 km east of Cholmondeley Sound (Rogers and Hart 1978). Today, remnants of stone-constructed fish traps, once used by Haidas or Tlingits during the summer and fall salmon fishing seasons, can be seen in a few of the coves in Cholmondeley Sound.

In the early 1900's, white settlers established a post office and salmon cannery on the south side of Cholmondeley's west arm. The post office closed in 1930, but the cannery remained active until the mid 1900's (Orth 1971). Bricks, sheets of tin, and rotting lumber, once part of the small settlement of Chomly are still present along the coast of this area. Also, a few of the pilings upon which the cannery was originally constructed still stand.

Fox farming was established on some of the offshore islands in Cholmondeley Sound during the early 1900's. The islands today are dotted with the ruins of these fur farms which failed during the 1930's when the fur market crashed. Trapping of mink and otters has provided a source of income for one or two local trappers since around the turn of the century (N. Olson, pers. commun.). Marten have been trapped since shortly after their introduction in 1934. Presently, one person traps in Cholmondeley Sound.

In 1951 several billion board feet of timber from an allotment on Prince of Wales Island were sold to the Ketchikan Pulp Company of Bellingham, Washington. A substantial increase in annual cuts occurred in 1954 when the first large pulpmill opened near Ketchikan (Harris et al. 1974). Clearcut logging first occurred in Cholmondeley Sound in 1957 and was followed by cuts in 1966-1969, 1971, 1973, and 1978.

CAPTURE, IMMOBILIZATION, AND BIOTELEMETRY

MATERIALS AND METHODS

Four types of traps were set in an effort to capture otters: number 4 double-spring leg-hold, number 44 jump leg-hold, Hancock beaver live traps, and a floating trap. The leg-hold traps were set in depressions dug in otter runs and camouflaged with a light covering of hemlock and/or spruce needles. Hancock traps were also placed in otter runs and covered with soil, grass, and/or conifer needles. To prevent escape of otters, Hancock traps were modified as recommended by Northcott and Slade (1976) and Melquist and Hornocker (1979).

A floating trap, modeled after one described by Melquist and Hornocker (1979), was constructed with wood and chain-link fencing and buoyed up with polystyrene foam. The trap was baited with live rockfish (*Sebastes* spp.) and/or sculpins (Cottidae) and placed within 10-15 m of the shore where water depth was between 6 and 12 m. All traps were checked daily except when inclement weather made it impossible to do so.

Captured otters were drugged at the capture site with intramuscular injections of ketamine hydrochloride combined with acepromazine maleate in a ratio of 10:1. The combination of acepromazine maleate and ketamine hydrochloride appears to overcome the problem of muscle rigidity (Ramsden et al. 1976). The drug was administered to otters at a dosage of about 22 mg/kg. Otters were transported by boat to a wooden holding pen (0.61 m x 0.61 m x 2.44 m) located at the field camp and confined there until an airplane could be dispatched to transport them to Ketchikan (Fig. 1, pg. 6) where radio-transmitters were surgically implanted. Sedated otters were placed in an airline travel cage for the flight from the field camp to Ketchikan and the ensuing drive to the veterinary clinic.

Otters were anaesthetized with halothane during surgery. Cylindrical transmitters constructed by Telonics, Inc. were implanted in their intraperitoneal cavities by a local veterinarian. The implant procedure has been described by Melquist and Hornocker (1979). Transmitters were 10 cm x 4 cm, weighed approximately 130 g, and operated at a frequency of 150 MHz. The transmitter batteries had a life expectancy of 12-17 months. Otters were marked with numbered fingerling size ear-tags made of Monel metal.

Instrumented otters were usually located from a boat using a 2-element Yagi antenna mounted on the end of a 2-m wooden pole. A DeHavilland Beaver airplane with 2-element Yagi antennas attached to each wing strut was used to search for otters when they could not be located from the boat. Radio range on the ground or across water was usually less than 1 km; most locations were determined at distances of less than 200 m. Maximum air-to-ground range was about 3 km while flying 300 m above the ground. Rocks, soil, and water decreased range considerably and, on occasion, totally excluded signal reception.

An attempt was made to locate instrumented otters each day. Otters generally restricted use of land areas to a narrow strip of timber (usually <20 m) adjacent to the beach. This made it practical to determine exact locations of radio-tagged otters in most cases.

Location, time, and habitat type were recorded each time an otter was located.

RESULTS AND DISCUSSION

Poor capture rates were obtained with all four trap types. Number 4 leg-hold traps were the only successful traps with a ratio of one capture:246 trap nights (Table 1). Otters escaped from leg-hold and Hancock traps 33 times as indicated by the presence of toes in traps, fresh scats in the vicinity of sprung traps, and/or sprung traps lying together with piles of forest litter and moss which otters had scraped together while attempting to free themselves. One otter apparently escaped from a Hancock trap because part of its body was caught between the edges of the closing sides of the trap, thereby preventing the trap from closing completely and locking. D. Reid and G. Stenson (pers. commun.) experienced similar escapes while trapping otters in Alberta and British Columbia, Canada, respectively.

Floating traps have been effective at capturing otters in or near fish hatcheries where the otters may cause predation problems (G. Stenson, pers. commun.). In this study, however, no otters were caught in floating traps.

Three non-target species were captured incidentally while trapping otters (Table 1). Four of 12 trapped mink and one of two trapped marten died of hypothermia. Other non-target animals were released. The one raven captured in a leg-hold trap was killed and eaten by a bald eagle. Two others, caught in Hancocks as a direct result of having bait near the traps, were released, wet but apparently unharmed.

Table 1. Results of trapping effort on the Cholmondeley Sound study area, December 1980 - July 1981.

Trap type	Trap Nights	Captures		Otter escapes
		Otters	Non-target	
No. 4 leg-hold	1,479	6	12 mink 2 marten 1 raven	26
No. 44 leg-hold	79	0	0	4
Hancock	181	0	2 ravens[a]	3
Floating	31	0	0	0
Totals	1,770	6	17	33

[a] Result of having bait near the trap.

Four female and two male otters were captured during the course of the study (Table 2). Two of the females died of hypothermia when a storm on the study area made it impossible to check traps for three consecutive days.

Female 02 was last located on 7 May 1981, two and a half months after she was released. At the time of her last location the transmitter was emitting long, drawn-out signals rather than the normal short, sharp signals. Seven unsuccessful telemetry flights were made to try to locate 02 after she was located on 7 May. Her transmitter may have prematurely ceased functioning. Transmitter life during the study varied from 79 to 340 days.

The carcass of female 04 was recovered from a burrow on 6 August 1981, a week after she was first located at the site. Some of the sutures used to close the opening through which the transmitter was implanted had broken, leaving an opening in the body wall. Bacterial infection was the probable cause of death.

The fates of males 01 and 03 are unknown. Eight separate attempts to locate male 01 were unsuccessful after he was last located on 27 November 1981. His radio signal was received for 11 months and throughout this period locations were obtained relatively easily. His transmitter probably ceased functioning. The radio signal for male 03 was received for only three and a half months, and at the time of his last location on 18 October 1981 a strong and steady signal was received. It is unlikely, therefore, that his transmitter failed shortly after 18 October. He may have dispersed out of the Cholmondeley Sound area. However, Melquist and Hornocker (1983) observed dispersal of

Table 2. Information about otters captured on the Cholmondeley Sound study area, 1980-1981.

Ident. number	Radio freq. (MHz)	Sex	Age[a]	Weight (kg)	Trap type	Capture date	Transmitter implant date	Release date	Last location date	Total locations	Fate
01	150.87	M	Adult	11.8	#4 leg-hold	24 Dec '80	24 Dec '80	26 Dec '80	27 Nov '81	178	Transmitter failure (?)
02	150.85	F	Adult	11.8	#4 leg-hold	16 Feb '81	18 Feb '81	20 Feb '81	7 May '81	14	Transmitter failure (?)
08	----	F	Adult	7.7[b]	#4 leg-hold	10 Mar '81	----	----	----	----	Died in trap
09	----	F	Adult	8.2[b]	#4 leg-hold	10 Mar '81	----	----	----	----	Died in trap
03	150.89	M	Yearling	9.5	#4 leg-hold	1 Jul '81	2 Jul '81	3 Jul '81	18 Oct '81	28	Unknown
04	150.91	F	Adult	8.6	#4 leg-hold	4 Jul '81	6 Jul '81	7 Jul '81	29 Jul '81	5	Died

[a] Yearlings were 1-2 years old, adults were > 2 years old.
[b] Weight of animal without pelt.

otters in Idaho occurring in April and May at 12-13 months of age. Assuming similar dispersal patterns for otters inhabiting Cholmondeley Sound, it is unlikely that male 03 dispersed in October at an estimated age of 17 months. Two attempts to locate him using an aircraft were unsuccessful even though the flights were extensive, covering several km^2 of habitat both north and south of Cholmondeley Sound. It is also possible that he fell prey to a pod of killer whales which were observed moving through the area where 03 was last located. Two days prior to the arrival of the whales male 03 was observed swimming between Chasina Point and Skin Island, a distance of approximately 3.3 km (Fig. 1, pg. 6). If the killer whales intercepted him enroute between these land masses they could easily have consumed him.

HABITAT USE

The habitat requirements of river otters in coastal environments have not previously been reported. Traditionally, river otter habitat was viewed rather simply as riparian areas adjacent to freshwater lakes, ponds, rivers, and creeks containing prey. While this has been shown to be true for otters inhabiting inland areas of North America (Mowbray et al. 1979, Melquist and Hornocker 1983), otters living in coastal areas of Alaska and Europe have been shown to use a narrow fringe of timbered habitat adjacent to the marine coast and only occasionally move into inland habitats (Kruuk and Hewson 1978; Woolington, in prep.; this study).

Information presented here should prove helpful to wildlife biologists and land managers in their efforts to develop land use practices which take into consideration the habitat requirements of river otters.

MATERIALS AND METHODS

Line transects and radio-telemetry were used to collect information concerning use of habitats by otters. Four habitat types were identified within the Cholmondeley Sound area using the classification system designed by the USDA Forest Service and produced on their timber type maps at a scale of 1:34,680. Habitat types included old growth high volume stands ($\geq$30,000 bd. ft. Scribner/acre), old growth low volume stands (8,000-29,000 bd. ft. Scribner/acre), second growth stands (60-70 years old), and clearcut stands (5-20 years old). Second growth stands in this study were largely resultant of fires which occurred during the early 1900's. Residual beach fringe stands were also identified as a discrete habitat type. These were stands consisting of a narrow (usually <60 m) fringe of old growth timber adjacent to the beach, behind which clearcut logging had occurred between 1966 and 1973.

The BMDP Biomedical Computer Programs (Dixon et al. 1981) were used to compute basic statistics, construct frequency distributions and bivariate (scatter) plot diagrams, and test for normality. Abundance of otter signs displayed significant deviations from normality due to the occurrence of a few large values and many zero values. Therefore, all data collected during this study were analyzed using nonparametric statistical methods. Kruskal-Wallis one way analysis of variance (BMDP/3S), pairwise comparisons (Conover 1980:231), chi-square goodness of fit analysis (BMDP/4F), and Spearman's rank correlation coefficients (BMDP/3S) were used to examine relationships between habitat variables and abundance of otter signs.

LINE TRANSECTS

Line transects extending perpendicularly away from the beach into the forest were established and run from June through August 1980 and September through November 1981. Line transects paralleling the beach within the forested habitats were established and run from August through November 1981. All otter signs found on the perpendicular and parallel transects were recorded and served as an index to the amount of otter use within each of the five habitat types.

Perpendicular transects 1980

Three hundred fifty-three line transects perpendicular to the beach were run during 1980. These extended from the edge of the forested habitats adjacent to the beach a distance of 20 m inland. Transects were 4 m wide and were systematically placed at 65 m intervals within each habitat type, beginning 65 m from adjacent habitat types. The numbers of transects run in each of the five habitats follow:

1. Old growth high volume	118
2. Old growth low volume	76
3. Second growth	57
4. Clearcut	62
5. Residual beach fringe	40

The percent slope of the forest floor at each transect was determined using a clinometer. Aspect was determined with the use of a directional compass.

Characteristics of a 30 m wide strip of beach extending from the forest to the mean low tide mark adjacent to each transect were recorded. The percentage of the beach consisting of bedrock (solid, mostly unbroken but sometimes slightly fissured rock), boulders (≥25 cm dia.), and fine particles (gravel, sand, and mud) was recorded using the classification scheme of Daubenmire and Daubenmire (1968): >0-5%, >5-25%, >25-50%, >50-75%, >75-95%, >95-100%. Midpoints of the classes were used during analyses of these data (e.g. >0-5% was 2.5%, >5-25% was 15%, etc.). Gravel, sand, and mud were combined into one grouping. The percentage of the beach covered by algae (*Fucus* spp.) was also recorded using the same classification scheme. Vegetational debris (washed up logs and branches or fallen trees extending out from the forest) on beaches adjacent to transects was recorded as light (<33% covered), medium ($\geq$33-66% covered), or heavy (>66% covered). Intertidal length (distance from high tide mark to mean low tide mark) adjacent to transects was measured during low tides. The general configuration of beaches adjacent to transects was recorded as convex (point), concave (bight), or straight.

Otter signs found within the boundaries of the 80 m^2 transects were recorded according to the meter at which they occurred; meter one being closest to the beach and meter 20 furthest from the beach. Signs included scats, scat/mark piles, mark piles, runs, burrows, and food remains. The presence of a sign type was recorded as 1.0.

Scats were different from scat/mark piles in that scats by themselves were usually deposited on the flat surface of the ground whereas scats associated with scat/mark piles were deposited on top of mounds of forest litter and moss which otters had scraped together. Some of these mounds were up to 0.3 m^2 in size. Mark piles were similar to scat/mark piles except that instead of scats being present, either anal sac secretions (Gorman et al. 1978) had been deposited on the mounds or otters had urinated on the mounds (Kruuk and Hewson 1978). The numbers of scats, including those on scat/mark piles, were summed and recorded at each one-meter interval along transects.

Runs were identified as well-worn trails oriented parallel and/or perpendicular to beaches. Runs usually lead from beaches to resting (burrow), feeding, and/or marking sites. The presence of runs was recorded at each meter in which they partially or completely overlapped transects.

Otter burrows were recognized as natural cavities usually located under the roots of large conifers or decaying snags. Cavities were only recorded as being otter burrows if two criteria were met:

1. Cavities had at least two otter scats within 20 m of at least one entrance (Reid 1981).
2. At least one entrance was well worn with forest litter removed and dark soil exposed.

Remains of food items consumed by otters were occasionally found alone or together with other otter signs. These consisted primarily of fish bones and carcasses, shells of abalone (*Maliotus kamtschatkana*), exoskeletons of sea urchins (*Strongylocentrotus* spp.), legs of starfish (*Pisaster ochraceus*), and plates and girdles of chitons (*Tonicella lineata*).

Perpendicular transects 1981

During 1981, 166 of the original 353 perpendicular transects were rerun and seven additional perpendicular transects were established and run in residual beach fringe habitat. Of the original 353, all transects containing any otter signs during 1980 were rerun along with 114 randomly selected transects on which no sign had been found during 1980.

Three circular plots, each with a radius of 3.58 m were established along the lengths of the 173 transects. The first plot was centered at 3.58 m inland from the edge of the forest, the second at 10.74 m inland,

and the third at 17.9 m inland. Five hundred nineteen circular plots were established and surveyed: Old growth high volume, 126; old growth low volume, 114; second growth, 96; clearcut, 84; and residual beach fringe, 99. Within the 0.004 ha area of each plot, percent cover of *Vaccinium* spp., rusty menziesia, salal, *Rubus* spp., *Ribes* spp., and devilsclub was estimated and recorded according to the classification scheme of Daubenmire and Daubenmire (1968). Percent canopy closure above each plot was also estimated and recorded according to the same classification scheme.

The number of individuals of each tree species growing within each plot was recorded. Trees growing on the borders of plots were included as long as they were at least partially within the plots. In approximately 5-10% of the plots, trees occurred on the border between two adjacent plots. These trees were included in both plots. For the purposes of analyses, the number of trees of each species within each plot were assigned to classes: 0-4, 5-8, 9-12, 13-16, 17-20, 21-24, or 25-28. Similarly, diameter at breast height (dbh) was recorded for each tree species and snag within each plot. Tree and snag dbh's were measured to the nearest centimeter and assigned to classes: 0-25 cm, 26-51 cm, 52-76 cm, 77-102 cm, 103-127 cm, 128-152 cm, 153-178 cm or 179-203 cm.

It should be noted that by including all trees which even partially occurred within plots, the probability of counting and measuring large trees was greater than the probability of counting and measuring small trees. To avoid this bias, trees should only have been included if their centers were within the borders of plots.

Otter signs encountered along transects were recorded according to the plot in which they occurred. The amount of sign within each plot was summed separately. This allowed comparisons to be made between the amount of sign and vegetational characteristics, both between timber types and between plots within timber types (Appendix D).

To facilitate use of statistical analyses, a three-digit value was assigned to each plot representing the quantity of sign encountered. The first digit (hundreds) represented the number of different sign types found, the last two digits (tens and ones) represented the total amount of sign present. All sign types except scats were given a value of one when encountered on transects. Unlike the number assignment used in 1980, scats observed along trasect in 1981 were assigned values of one, indicating a single scat; three, indicating two to five scats; or six, indicating a latrine with > five scats. As an example; six scats, two mark piles, one burrow, one run, and three food remains would be recorded as 513; where 5 represents five types of signs and 13 represents the summed total of all signs.

Parallel transects

Results from the original perpendicular transects run during 1980 indicated that most otter signs in the forest occurred within 14 m of the beach. Therefore, to maximize the amount of sign seen per sampling effort, nine transects paralleling shorelines were established within the 14 m intense use zone and run in the five habitat types during 1981. The purpose of these transects was twofold:

1. To identify potential associations of otter signs with

microhabitat characterists within each macrohabitat type; and

2. To determine spatial distribution of otter burrows within each habitat type.

Transects were continuous and varied in length from 0.8-1.6 km. An attempt was made to run at least one 1.6 km transect in each habitat type. However, the longest homogeneous stretch of residual beach fringe habitat was only 1.2 km. Parallel transects were divided among the five habitat types as follows:

	No. of transects	Length(s)
1. Old growth high volume	3	1.6,0.8,0.8 km
2. Old growth low volume	3	1.6,0.8,0.8 km
3. Second growth	1	1.6 km
4. Clearcut	1	1.6 km
5. Residual beach fringe	1	1.2 km

Each transect was divided into 80 m-long plots; each plot was divided into five equally spaced circular subplots, each with a radius of 3.58 m. Transects were approximately 10 m wide. It was possible to search for otter signs over such a large area because signs were highly visible. Otter signs were recorded according to the plots in which they occurred. When trails extending from the beach up into the forest were encountered, they were followed to see whether or not they led to otter burrows. If so, burrow characteristcs were recorded (*see* methods, Burrow Characteristics, pg. 30).

Parallel transect locations were determined by referring to a timber type map. Selection was biased to areas with similar lengths of convex, concave, and straight shorelines so potential associations of otters with these configurations could be identified. In the case of second growth, clearcut, and residual beach fringe habitats, only one location in each type extended continuously for long enough distances to allow their inclusion.

Starting points of transects were marked with survey flagging. Paralleling the shore at a distance of approximately 6 m inland, a distance of 8 m was measured using a loggers tape. At that point a circular subplot with a radius of 3.58 m was established. Within the subplot, percent cover of *Vaccinium* spp., rusty menziesia, salal, *Rubus* spp., *Ribes* spp., and devilsclub was estimated using Daubenmire and Daubenmire's (1968) classification scheme. Percent canopy closure above the subplot was also estimated according to this scheme.

The number of individuals of each tree species growing within the subplot was recorded along with each one's dbh. Trees growing on the border of the subplot were included as long as they were at least partially within the subplot. Decaying snags were counted, and the dbh of each one measured.

A distance of 16 m was next measured from the center of the first subplot to the center of the second. At the second subplot percent cover of shrub species was again recorded along with percent canopy closure. However, the number of trees and their associated dbhs, were only recorded at the first, third, and fifth subplots of each plot.

The distance between the second and third, third and fourth, and fourth and fifth subplots was 16 m. From the center of the fifth subplot an additional distance of 8 m was measured and that point was flagged to mark the end of the 80 m plot. Subsequent plots along the transects were established and run in the same manner. Ten plots (50 subplots) were established within each 0.8 km of transect.

Midpoint values of the Daubenmire and Daubenmire (1968) percent cover classes were assigned to all shrub species within each subplot (e.g. >0-5% was assigned a percent cover value of 2.5%, >5-25% was assigned a value of 15%, etc.). Percent canopy closure was assigned a midpoint value in the same manner. The percent cover of each shrub species within each subplot was summed and divided by 5 (subplots) to arrive at mean cover values for each shrub species within each plot. Mean percent canopy closure for each plot was derived in the same manner.

The number of individuals of each tree species and the number of decaying snags within the first, third, and fifth subplots of each plot was summed. Mean dbh of each tree species and of snags within each plot was determined by summing the dbh's of each species within the three subplots and dividing by the corresponding number of dbh measurements.

Characteristics of beaches adjacent to each 80 m plot were recorded. The percentage of the beach consisting of bedrock, boulder, and fine particles (gravel, sand, and mud) was recorded using Daubenmire and Daubenmire's (1968) classification scheme. The percentage of the beach covered by algae was also recorded using this scheme. Vegetational debris on beaches adjacent to plots was recorded as light (<33% covered), medium (≥33-66% covered) or heavy (>66% covered). Intertidal lengths adjacent to plots were measured during low tides, and the general configuration of the beaches was recorded as convex, concave, or straight.

RADIO-TELEMETRY

Each of the sites used for extended daytime periods (i.e. resting) by radio-tagged otters was assigned one of six habitat classifications according to the timber type maps; old growth high volume, old growth low volume, second growth, clearcut, residual beach fringe, or islands (islands were included as a discrete habitat type in this portion of the study). The number of locations obtained within each habitat type were summed separately for each radio-tagged otter. The total amount of each habitat available to a radio-tagged otter was determined by measuring the amount of shoreline located adjacent to each of the six habitat types within that otter's respective home range. To determine preference or avoidance of each habitat type by radio-tagged otters, chi-square analyses and a Bonferroni z-statistic (Neu et al. 1974) were used.

BURROW CHARACTERISTICS

Otter burrows encountered while running transects and burrows detected by locating radio-tagged otters were characterized. A circular plot with a radius of 3.58 m and centered on the burrow was established around each burrow.

Shrub cover, canopy closure, the numbers of each tree species and each tree's dbh within each burrow plot were recorded in the same manner as was done for plots and subplots along transects. For analyses, breakdowns of 0-3, 4-6, 7-9, etc., trees per plot were used. Hemlock diameters were separated into two classes: 0-51 cm and >51 cm. Cedars were separated into eight classes: 0-23 cm , 24-49 cm, 50-74 cm, 75-99 cm, 100-125 cm, 126-150 cm 151-175 cm, and >175 cm. Spruce diameters were divided into seven classes: 0-15 cm, 16-33 cm, 34-51 cm, 52-69 cm, 70-86 cm, 87-104 cm, and >104 cm. Alders were divided into two classes: 0-8 cm and >8 cm; snags into three classes: 0-38 cm, 39-79 cm, and >79 cm; and the total mean dbh of all trees and snags in each plot was separated into two classes: 0-51 cm and >51 cm. Also, the number of stems in each plot which was greater than 51 cm dbh were separated into three classes: 0-1, 2-3, and >3 stems. The number of stems greater than 76 cm dbh in each plot was separated into two classes: 0-1 and >1 stems. Additionally, the structure in or under which burrows were located was noted (i.e. hemlock tree, snag, soil, etc.). The dbh's of trees and snags associated with burrows were also measured and recorded.

Beach characteristics, including percent cover of bedrock, boulder, fine particles (gravel, sand, and mud), and algae adjacent to burrow locations were recorded. Intertidal lengths adjacent to burrows were noted along with general beach configuration; convex, concave, or straight.

Other characteristics which were recorded at burrows included: Habitat type, aspect, slope of the forest floor between the burrow and the beach, distance from the burrow to the beach, presence or absence of freshwater, number of openings in the burrow, and presence or absence of external beds (small, concave depressions compacted by resting otters and usually located within 1-2 m of burrows). Distances between burrows encountered on parallel transects were measured.

RESULTS AND DISCUSSION

Five to 20 year old clearcuts were avoided by otters in this study. Old growth high volume, old growth low volume, 60-70 year old second growth, residual beach fringe, and island habitats were used in proportion to their availability. Otter use of habitats was not equally distributed throughout the study area. For example, one of three parallel transects established in old growth high volume habitat contained significantly more otter signs than did the other two ($P < 0.05$).

River otters in this study appeared to select habitats based on beach characteristics adjacent to the habitats. Convex shorelines, short intertidal lengths, and a predominance of bedrock substrate were the beach characteristics selected by otters. However, even preferred beach characteristics adjacent to clearcuts did not entice otters to use clearcut habitats where there was dense shrub cover with logging slash.

Most of the measured or estimated microhabitat characteristics were not found to be associated with otter use of habitats. This may reflect the relative unimportance of independently analyzed microhabitat vegetation characteristics within macrohabitats; however, it is also possible that features which are important to otters were not measured. Microhabitats with large trees (i.e. >51 cm dbh) were generally used more often than microhabitats without large trees. This was further reflected by the size of trees and snags associated with otter burrows; mean dbh was 85 cm.

PERPENDICULAR TRANSECTS

The numbers of perpendicular transects with and without otter signs which were run in each of the five habitat types during 1981 were as follows:

	With sign	Without sign
1. Old growth high volume	19	23
2. Old growth low volume	13	25
3. Second growth	12	20
4. Clearcut	4	24
5. Residual beach fringe	11	22

A chi-square goodness of fit analysis together with a Bonferroni z-statistic (Neu et al. 1974) was used to determine macrohabitat (i.e. habitat type) selection by otters. Using transects as the sample units, otter signs were encountered on the proportion of transects within old growth high volume, old growth low volume, second growth, and residual beach fringe habitats as expected ($P > 0.05$) (Table 3). However, fewer transects than expected within clearcut habitat contained otter signs ($P < 0.05$) (Table 3). Similarly, using the 519 circular plots as the sample units and subjecting the data to a Kruskal-Wallis test followed by pairwise comparisons, the amount of otter sign in clearcut habitat was found to be significantly less than in the other four habitats (H = 19.4, 4 df, $P < 0.05$).

Although no information was found in the literature which addressed impacts from logging on otters, Soutiere (1978) found that marten in north-central Maine rarely used 0-15 year old clearcut areas. Soutiere (1978) suggested that this was due to the presence of compact logging

Table 3. Use of habitat types by river otters as determined from otter signs occurring on perpendicular transects, 1980. Proportions of total transects represent expected number of transects with otter signs as if signs occurred in each habitat in exact proportion to availability.

Habitat type	No. of transects	Proportion of total transects (P_{io})	No. of transects with sign	Expected no. of transects with sign[a]	Proportion of transects containing signs in each habitat type ($\bar{P}_i$)	95% CI (P_i)[b]
Old growth high volume	118	0.334	18	16.7	0.36	$0.185 \leq P_1 \leq 0.535$
Old growth low volume	76	0.215	14	10.8	0.28	$0.116 \leq P_2 \leq 0.444$
Second growth	57	0.161	10	8.1	0.20	$0.054 \leq P_3 \leq 0.346$
Clearcut	62	0.175	2	8.8	0.04	$0.031 \leq P_4 \leq 0.111$
Residual beach fringe	40	0.113	6	5.6	0.12	$0.002 \leq P_5 \leq 0.238$
Totals	353		50	50		

[a] Calculated by multiplying proportion P_{io} x N; i.e. 0.334 x 50 = 16.7.

[b] P_i represent theoretical proportion of occurrence and is compared to corresponding P_{io} to determine if hypothesis of proportional use is accepted or rejected, i.e., $\bar{P}_i = P_{io}$. CI calculated as $\bar{P}_i \pm z \sqrt{\bar{P}_i (1 - \bar{P}_i)/N}$.

slash which, during the winter, was quickly blanketed with snow, making access to prey difficult. Under-utilization of clearcut areas by river otters in Cholmondeley Sound probably was due, at least in part, to the dense shrub growth which spreads quickly after clearcutting and to the presence of slash resulting from logging operations. The combination of trees cut and left, fallen snags, cut tree limbs, conifer seedlings, and dense shrub growth on the forest floor results in a formidable vegetative labyrinth. River otters in this study tended to use areas relatively free of extensive vegetative debris and dense shrub cover (*see* pg. 46).

Although 5-20 year old clearcuts appeared to be avoided by otters, 60-70 year old second growth stands were used in the amount expected. There may be a stage in the development of regenerating stands where the habitat once again becomes suitable to otters. However, the fact that the second growth stands which were sampled in this study resulted from fire rather than cutting leaves this question unanswered; logging slash is not present on regenerating burn sites. If, as previously suggested, otters avoid clearcuts because of slash, its absence from burned stands may result in future use of the stands by otters. In clearcuts, where slash persists, it may take much longer before otters move back in. To answer this question, studies are needed which address use of various aged clearcut stands (i.e. 30, 40, 50 years) by otters.

A chi-square goodness of fit analysis was used to determine whether or not perpendicular transects having specific aspects were used by otters in proportion to their occurrence. Aspect was divided into eight classes: North, northeast, east, southeast, south, southwest, west, and northwest. No differential use seemed to exist ($X^2 = 3.03$, 7 df, $0.90 > P > 0.75$).

Slope of the forest floor at each perpendicular transect was measured in percent and ranged from 0-99 (zero percent is level, 100% is 45 degrees). The mean percent slope for transects with otter signs was 32.6% ($N = 47$), and for transects without otter signs 31.4% ($N = 302$). A calculated Spearman's rank correlation coefficient showed no significant correlation between slope and amount of otter signs present ($r_s = 0.03$, $N = 349$, $P > 0.50$).

Characteristics of beaches adjacent to perpendicular transects were analyzed together with the amount of otter signs found on the associated transects. This made it possible to identify beach characteristics associated with haul-out sites selected by otters. Transects within each habitat type adjacent to convex, concave, and straight configurations were summed separately (Table 4). A Kruskal-Wallis test indicated significantly greater use of at least one of the three configurations ($H = 50.9$, 2 df, $P < 0.001$). Based on a pairwise comparisons test, habitats adjacent to convex configurations were used significantly more than those adjacent to concave and straight configurations ($P < 0.05$). Habitats adjacent to concave and straight configurations were used by otters in proportion to their occurrence on the study area ($P > 0.05$).

Otter selection of habitats adjacent to convex shorelines having short intertidal lengths and consisting predominantly of bedrock substrate was probably at least partially related to two factors: Prey

Table 4. Number of perpendicular transects established adjacent to convex, concave, and straight shorelines in Cholmondeley Sound and percent of transects containing otter signs, 1980.

Habitat type	Configuration	Total transects *N*	No. transects with signs	% of transects with signs
Old growth high volume	Convex	26	10	38
	Concave	31	1	3
	Straight	61	7	11
Old growth low volume	Convex	19	10	53
	Concave	17	2	12
	Straight	40	2	5
Second growth	Convex	12	6	50
	Concave	10	0	0
	Straight	35	4	11
Clearcut	Convex	5	0	0
	Concave	22	1	4
	Straight	35	1	3
Residual beach fringe	Convex	7	2	28
	Concave	7	2	28
	Straight	26	2	8
Totals	Convex	69	28	40
	Concave	87	6	7
	Straight	197	16	8

species associated with convex areas, and the relatively short distances separating the aquatic and terrestrial habitats at convex sites. Cottids, scorpaenids, and hexagrammids occurred most frequently in otter scats collected during this study (*see* Feeding Habits section, pg. 119). These fish often occur in intertidal areas with fairly steep beaches, often located proximal to convex shorelines (Hart 1973). Pholids and stichaeids, on the other hand, usually occur in shallow waters adjacent to gently sloping beaches with long intertidal lengths. Those prey occurred infrequently in otter scats from this study (*see* Feeding Habits section, pg. 119). This suggests that use of convex shorelines by otters may be partly related to the food items which are available. This raises an important consideration; the ratio of the amount of aquatic habitat (coastal waters used for foraging) to the amount of terrestrial habitat is larger along convex shorelines than along concave shorelines. Assuming that otters haul-out in habitats proximal to feeding sites and assuming use of feeding sites is proportional to availability, the expected number of transects with otter signs in habitats adjacent to convex shorelines would be greater than the expected number in habitats adjacent to concave shorelines. Thus, the expected number of transects with signs in habitats adjacent to convex and concave shorelines should be calculated using the ratios of the amount of aquatic habitat to terrestrial habitat for all areas adjacent to convex and concave shorelines. It was not practical to do this because of the difficulty in measuring the amount of area consisting of aquatic and terrestrial habitats adjacent to convex and concave shorelines. Instead, a simple simulation model was developed in which the ratio of aquatic habitat to terrestrial habitat for convex shorelines was 2:1 and the ratio for concave shorelines 1:2. These ratios represented extremes and were considered conservative. The ratio of aquatic habitat to terrestrial habitat for straight shorelines was 1:1. Using these ratios, the expected number of transects with otter signs in habitats adjacent to straight shorelines was equal to the observed number (16) (Table 5). The expected number of transects with signs adjacent to convex shorelines was calculated by multiplying the proportion of transects with signs adjacent to straight shorelines (16 of 197) by 2 (2 aquatic habitats:1 terrestrial habitat), and this product was multiplied by the total number of transects adjacent to convex shorelines (69) (Table 5). The expected number of transects with signs adjacent to concave shorelines was calculated by multiplying the proportion of transects with signs adjacent to straight shorelines (16 of 197) by 0.5 (1 aquatic habitat:2 terrestrial habitats), and this product was multiplied by the total number of transects adjacent to concave shorelines (87). Chi-square results indicated significantly greater use of habitats adjacent to convex shorlines than expected (X = 31.9, 2 df, $P < 0.001$) (Table 5).

The second factor influencing otter use of habitats adjacent to convex shorelines may be related to the distance otters must travel between aquatic and terrestrial habitats. Otters, with their short limbs, webbed feet, and long tails, are not as well adapted for moving about on land as they are moving through water. From an adaptive standpoint, therefore, they probably prefer to spend as little time as possible moving from the water into the cover of the forest or vice

Table 5. Chi-square results of use of transects adjacent to convex, concave, and straight beach configurations by river otters in Cholmondeley Sound, 1980. Expected values represent values derived using a simulation model in which twice as much sign was expected in convex areas as was found in straight areas, and half as much sign was expected in concave areas as was found in straight areas.

	Beach Configuration					
Transects	Convex		Concave		Straight	
	Observed	Expected	Observed	Expected	Observed	Expected
With signs	28	11.2	6	3.5	16	16.0
Without signs	41	57.8	81	83.5	181	181.0
Total	69		87		197	

versa. During low tides, otters crossing beaches with long intertidal lengths would be more vulnerable to predators, including humans, than otters crossing the short, relatively steep beaches associated with convex areas.

Spearman's rank correlation coefficients were calculated for the remaining beach characteristics recorded adjacent to perpendicular transects (Table 6). Intertidal lengths were negatively correlated with the amount of otter sign found on adjacent transects. Mean intertidal length for transects with signs (N = 47) equaled 13.3 m, mean intertidal length for transects without signs (N = 306) equaled 20.6 m. The percent of the beach consisting of bedrock was positively correlated with the amount of otter sign found on adjacent transects (Table 6). Short intertidal lengths usually consisted predominantly of bedrock. Intertidal length was negatively correlated with the percent of the beach consisting of bedrock ($r_s = -0.60$, $N = 353$, $P < 0.001$). Similarly, the percent of the beach consisting of fine particles (gravel, sand, and mud) was negatively correlated with the amount of otter signs found on adjacent transects (Table 6) and the percent of the beach consisting of fine particles was positively correlated with intertidal length ($r_s =$ 0.70, $N = 353$, $P < 0.001$). The percent of the beach consisting of boulders or covered with algae had no apparent affect on selection of beach haul-out sites by otters. Vegetational debris on beaches was negatively correlated with otter signs on adjacent transects (Table 6). Most areas recorded as having heavy beach debris were adjacent to clearcut habitat. This again suggests that otters avoid areas having dense slash resulting from logging.

Table 6. Spearman's rank correlation coefficients between beach characteristics and amount of otter signs on 353 adjacent perpendicular transects in Cholmondeley Sound, 1980.

Beach characteristic	r_s	Probability level
Intertidal length	-0.31	$P < 0.001$
Bedrock	0.35	$P < 0.001$
Boulder	0.00	$P > 0.5$
Gravel, sand, mud	-0.32	$P < 0.001$
Algae	-0.05	$0.20 < P < 0.5$
Vegatitive debris	-0.14	$0.005 < P < 0.011$

Microhabitat characteristics within old growth high volume, old growth low volume, second growth, clearcut, and residual beach fringe habitats were recorded and analyzed in order to determine whether or not otters selected particular microhabitat characteristics within the macrohabitats. Mean values for each of the measured or estimated characteristics were also calculated. Values for some of the microhabitat variables recorded for plots established in clearcut habitat differed considerably from those recorded in the other four habitats (Table 7, Appendix D). For example, *Rubus* was much more abundant in clearcuts than elsewhere. *Rubus* is a competitor with conifer seedlings. Therefore, the number of trees in plots established in clearcuts was similar to the number of trees in plots established in high volume, low volume, and residual beach fringe habitats (Table 7). However, the average dbh values were much lower in clearcut habitat than in the other habitats. Percent canopy closure in clearcuts was also much lower than in the other habitats.

Within old growth low volume habitat, plots containing at least one cedar tree with a dbh of 104-127 cm were used significantly more by otters than plots containing cedars with dbh's of 0-25 cm, 26-51 cm, 52-76 cm, or 129-152 cm ($H = 11.9$, 5 df, $P < 0.05$). Within second growth habitat, plots containing >5-25% or >25-50% rusty menziesia cover were used significantly more by otters than plots containing >0-5% rusty menziesia ($H = 20.1$, 3 df, $P < 0.05$). Plots containing 9-12 cedar trees within second growth were used significantly more than plots having 0-4 cedars ($H = 16.3$, 6 df, $P < 0.05$). Similarly, plots with 5-8 spruce trees were used more by otters than plots with 0-4 spruce trees in

Table 7. Mean shrub and canopy cover (%) on circular plots established on perpendicular transects in Cholmondeley Sound, mean number of trees and snags on each plot, and mean dbh (cm) of trees and snags in the five habitat types, 1980-81.

Habitat type	*N* transects	Mean shrub cover *Vaccinium*	*Menziesia*	Salal	*Rubus*	*Oplopanax*	Canopy closure	Mean number of stems per plot Hemlock	Cedar	Spruce	Alder	Snag	Total	Mean dbh per habitat type Hemlock	Cedar	Spruce	Alder	Snag	Total
Old growth high volume	126	36	11	6	5	4	29	4.2	0.5	0.7	0.3	0.8	6.5	15.0	47.0	14.5	7.4	47.2	21.1
Old growth low volume	114	37	12	43	4	2	35	4.5	1.4	0.4	0.9	1.2	8.4	12.4	29.5	15.2	6.3	45.5	19.5
Second growth	96	23	15	9	6	2	41	5.2	5.6	1.7	0.8	2.8	16.1	12.9	9.6	15.7	10.2	28.9	14.7
Clearcut	84	22	9	3	37	6	9	3.9	0.8	1.6	0.6	0.4	7.3	4.8	3.8	3.8	4.8	62.7	7.9
Residual beach fringe	99	32	13	8	13	4	23	4.9	0.3	0.9	0.4	0.9	7.4	9.9	50.8	15.5	4.1	64.5	18.0
Totals	519	31	12	14	11	4	28	4.5	1.6	1.0	0.6	1.2	9.0	9.0	30.0	13.3	6.6	49.2	16.8

second growth habitat ($H = 6.3$, 1 df, $P < 0.05$). In residual beach fringe habitat, significantly more otter signs were found in plots containing >25-50% rusty menziesia cover than in plots with >0-5% or >5-25% rusty menziesia cover ($H = 13.3$, 3 df, $P < 0.05$). Also, plots within residual beach fringe habitat having a canopy closure of >25-50% were used significantly more by otters than plots with a canopy closure of >0-5% ($H = 14.5$, 5 df, $P < 0.05$).

PARALLEL TRANSECTS

Macrohabitat selection by otters was determined using a Kruskal-Wallis test. Unlike the results obtained when the same analysis was applied to data collected along perpendicular transects, analyses of data collected along parallel transects indicated no preference or avoidance of any of the habitat types by otters, including clearcuts ($H = 6.5$, 4 df, $P = 0.16$). However, the sample mean for clearcut habitat was less than the means for the other four habitats. Otter signs encountered along the transect established in clearcut habitat consisted primarily of one or two scats or a food remain, usually within 1-4 m of the beach. It appeared that rather than spending extended periods of time in clearcuts (i.e. resting in burrows), otters hauled out in them and remained long enough to feed on a prey item they had captured and/or to defecate.

Beach configuration (convex, concave, or straight) adjacent to each 80 m-long plot was recorded; an analysis was run to determine whether or not there was preferential use of habitats adjacent to any of them. Habitats adjacent to convex shorelines were used significantly more than habitats adjacent to straight shorelines ($H = 6.5$, 2 df, $P < 0.05$). No differences were detected between use of habitats adjacent to convex and concave or concave and straight shorelines ($P > 0.05$).

Spearman's rank correlation coefficients were calculated for the additional beach characteristics recorded adjacent to parallel plots. Results were similar to those obtained when the same analysis was applied to beach characteristics recorded adjacent to perpendicular transects (Table 8).

The relationship between the amount of vegetative debris on beaches adjacent to parallel plots and the amount of otter signs on the plots was tested using Kruskal-Wallis and pairwise comparisons tests. Habitats adjacent to beaches with light (<33%) vegetative debris cover contained significantly more otter signs than did habitats adjacent to beaches having medium ($\geq$33-66%) or heavy (>66%) debris cover ($H = 10.9$, 2 df, $P < 0.05$). However, no significant difference in amount of sign was found between habitats adjacent to beaches moderately and heavily covered with vegetational debris ($P > 0.05$).

Shrub and tree characteristics associated with otter signs within all 135 parallel plots established in the five habitats were combined. A Kruskal-Wallis test showed that none of the shrub species within any of the six shrub cover classes contained more or less otter signs than any other cover class ($0.13 < P < 0.55$). However, a Spearman's rank correlation analysis indicated a negative correlation between the amount of *Rubus* and the amount of otter signs on plots ($r_s = -0.173$, $0.02 < P < 0.05$). *Rubus* occurs in greatest densities in openings in lowland forests such as those associated with clearcuts. The decline in otter

Table 8. Spearman's rank correlation coefficients between beach characteristics and amount of otter signs on 135 adjacent parallel plots established in Cholmondeley Sound, 1981.

Beach characteristic	r_s	Probability level
Intertidal length	-0.35	$P < 0.001$
Bedrock	0.26	$0.001 < P < 0.002$
Boulder	-0.02	$P > 0.05$
Gravel, sand, mud	-0.25	$0.002 < P < 0.005$
Algae	0.23	$0.005 < P < 0.01$

use associated with increasingly dense *Rubus* cover probably reflects avoidance of areas having dense shrub thickets.

Significantly more otter signs were found associated with canopy closures of >50–75% than with closures of >0–5% ($H = 8.4$, 3 df, $P < 0.05$). Also, although not significant, sample plots with >5–25% and >25–50% canopy closure contained more otter signs than did plots with closures of >0–5%. The amount of otter signs did not differ significantly among plots containing different numbers of each tree species according to a Kruskal-Wallis test.

RADIO TELEMETRY

Of the four otters outfitted with radio-transmitters, only male 01 used an area containing all six identified habitat types; recall that islands were included as a discrete habitat type in this part of the study. A chi-square analysis was run on the 178 habitat locations visited either briefly or for extended daytime periods by male 01. Significant differences ($0.005 < P < 0.01$) were detected between the observed and expected amount of use within at least one of the six habitat types. The methods of Neu et al. (1974) were used to determine which habitat types were selected or avoided. Confidence interval values for the theoretical proportions of occurrence in clearcut habitat could not be calculated for male 01 because he was never located in this habitat. Using a value of one (location in clearcut habitat) instead of the actual zero, male 01 still had fewer ($P < 0.05$) telemetry locations in clearcuts than expected based on the amount of these habitats available within his home range (Table 9). Second growth habitat was

Table 9. Use of habitat types for brief and extended periods by adult male 01 within his home range in Cholmondeley Sound, 1981. Proportions of total shoreline represent expected number of locations by male 01 as if he occurred in each habitat in exact proportion to availability. For clearcut, it was not possible to calculate CI values because male 01 was never located within it. However, similar to second growth which was used less than expected ($P < 0.05$), clearcut had the same expected value of 7.1.

Habitat type	Available shoreline within home range (km)	Proportion of total shoreline (P_{io})	No. of locations	Expected no. of locations[a]	Proportion of locations in ($\bar{P}_i$)	95% CI (P_i)[b]
Old growth high volume	6.4	0.160	39	28.5	0.219	$0.137 \leq P_1 \leq 0.301$
Old growth low volume	14.4	0.361	66	64.3	0.370	$0.274 \leq P_2 \leq 0.465$
Second growth	1.6	0.040	1	7.1	0.006	$0.009 \leq P_3 \leq 0.021$
Clearcut	1.6	0.040	0	7.1	0.000	$----- \leq P_4 \leq -----$
Residual beach fringe	1.2	0.030	5	5.3	0.028	$0.005 \leq P_5 \leq 0.061$
Island	14.7	0.369	67	65.7	0.376	$0.280 \leq P_6 \leq 0.472$
Totals	39.9		178	178		

[a] Calculated by multiplying proportion $P_{io} \times N$, i.e. $0.160 \times 178 = 28.5$.

[b] P_i represents theoretical proportion of occurrence and is compared to corresponding P_{io} to determine if hypothesis of proportional use is accepted or rejected, i.e., $\bar{P}_i = P_{io}$. CI calculated as $\bar{P}_i \pm Z\sqrt{\bar{P}_i(1 - \bar{P}_i)/N}$.

also used less than expected. The other four habitats were used in proportion to their availability.

Female 02 was located only 14 times before her transmitter presumably failed. She was located at the same burrow site in old growth low volume habitat for four consecutive days immediately after being released. Her continuous use of the burrow was probably due to trauma caused by the operation to implant the transmitter rather than selection of preferred habitat. For these reasons, no attempt was made to determine selection or avoidance of habitats by female 02.

Yearling male 03 used the four habitat types within his home range in proportion to their availability ($P < 0.05$) (Table 10); clearcut and residual beach fringe habitats did not occur within his home range.

Adult female 04 was located only five times prior to her death. Four locations were in old growth low volume habitat and one location in old growth high volume habitat. No attempt was made to determine selection or avoidance of habitats by female 04 because of the insufficient data.

BURROW CHARACTERISTICS

Natural cavities formed by the roots of coniferous trees and decaying snags were often encountered close to the beach throughout the study area. Several of these cavities had otter signs near them, indicating that they were used as burrows by otters. Information obtained by monitoring radio-tagged otters indicated that burrows were used most extensively as resting sites during the daytime. Kruuk and Hewson (1978) reported that otters (*L. lutra*) along the coast of

Table 10. Use of habitat types by yearling male 03 within his home range in Cholmondeley Sound, 1981. Proportions of total shoreline represent expected number of locations by male 03 as if he occurred in each habitat in exact proportion to availability.

Habitat type	Available shoreline within home range (km)	Proportion of total shoreline (P_{1o})	No. of locations	Expected no. of locations[a]	Proportion of locations in each habitat type ($\bar{P}_1$)	95% CI (P_1)[b]
Old growth high volume	4.0	0.210	3	5.9	0.107	$-0.039 \leq P_1 \leq 0.253$
Old growth low volume	9.2	0.484	16	13.5	0.571	$-0.337 \leq P_2 \leq 0.805$
Second growth	1.8	0.095	5	2.7	0.178	$-0.003 \leq P_3 \leq 0.359$
Island	4.0	0.210	4	5.9	0.143	$-0.022 \leq P_4 \leq 0.308$
Totals	19.0		28	28		

[a] Calculated by multiplying proportion P_{1o} X N, i.e. 0.210 x 28 = 5.9.

[b] P_1 represents theoretical proportion of occurrence and is compared to corresponding P_{1o} to determine if hypothesis of proportional use is accepted or rejected, i.e., $\bar{P}_1 = P_{1o}$. CI calculated as $\bar{P}_1 \pm 2\sqrt{\bar{P}_1 (1 - \bar{P}_1)/N}$.

northwest Scotland almost always slept in or close to burrows which were usually located within 20 m of the beach. Similarly, burrows used by otters in this study were located between 0.9 and 22.9 m from the beach ($\bar{x}$ = 5.4 m, N = 126, SD = 4.01).

Burrows were important to otters, as indicated by their repeated use as resting sites. As many burrows as possible were located and their surroundings examined to understand associations between microhabitats and burrows used by otters. Fourteen otter burrows were located during 1980 while I was running transects perpendicular to the beach. An additional 88 burrows were discovered while I was running transects parallel to the beach in 1981, and 38 burrows were discovered by following radio-tagged otters to resting sites. Some of the burrows which were found and characterized may have been used as natal dens by female otters with pups. However, Woolington (in prep.) reported that the five natal dens he identified on Baranof Island were approximately 0.8, 0.4, 0.5, 0.8, and 0.4 km inland from the beach. Therefore, it is possible that burrows located near the coast are used primarily as resting sites whereas cavities located inland are sought and used during the spring for pupping.

To compare microhabitats with and without burrows the 126 burrow plots characterized during 1981 were compared to 120 circular subplots which did not have burrows. The 120 plots without burrows were selected randomly from among the 675 plots in the five habitat types. Plots with and without burrows were identical in size (0.004 ha), and the same habitat characteristics were recorded for both.

The 14 otter burrows found in 1980 while running transects perpendicular to the beach were located on 11 transects and were divided among the five habitat types as follows: Old growth high volume, two transects, three burrows; old growth low volume, five transects, six burrows; second growth, three transects, four burrows; and residual beach fringe, one transect, one burrow. No burrows were encountered on transects established in clearcut habitat. Burrows occurred in each of the five habitats in proportion to the sampling effort within the habitats ($\chi^2 = 6.71$, 4 df, $0.10 < P < 0.25$). Similarly, the 135 plots associated with transects established parallel to beaches within the five habitat types in 1981 contained otter burrows in proportion to the number of plots established in each habitat ($\chi^2 = 6.36$, 4 df, $0.10 < P < 0.25$).

Otter burrows were located adjacent to convex shorelines more often than expected ($\chi^2 = 17.56$, $N = 246$, 2 df, $P = 0.0002$). Burrows adjacent to straight configurations occurred in proportion to the number of transects established adjacent to straight beaches. However, burrows adjacent to concave configurations were encountered less often than expected.

Mean values and Spearman's rank correlation coefficients were calculated for other beach characteristics adjacent to burrows (Table 11). Chi-square results indicated that there were more burrows than expected located adjacent to intertidal lengths of 6-12 m and fewer than expected adjacent to intertidal lengths of 19-24 m and 25-30 m ($\chi^2 = 39.9$, 4 df, $P < 0.001$). Beaches consisting of $\geq$75% bedrock had more burrows than expected in adjacent habitats whereas beaches consisting of <50% bedrock had fewer burrows than expected in adjacent

Table 11. Mean values for beach characteristics adjacent to otter burrows, 1980-1981, and Spearman's rank correlation coefficients between beach characteristics and otter signs on perpendicular transects established in Cholmondeley Sound, 1980.

Beach Characteristic	1980 Burrows Mean (*N*=14)	1981 Burrows Mean (*N*=125)	1980 Transects r_s (*N*=353)
Intertidal length	10.7 m	13.9 m	-0.19*
Bedrock	75.7 %	74.9 %	0.20*
Boulder	22.3 %	17.4 %	-0.02
Gravel	4.8 %	7.0 %	-0.19*
Algae	10.4 %	49.9 %	0.00
Veg. Debris	[a]	[b]	-0.09

* $P < 0.001$

[a] All transects had 0-33% vegetational debris.

[b] 94.4% had 0-33% debris; 4.8% had 34-66% debris; 0.8% had >66% debris.

habitats (X^2 = 57.1, 5 df, P < 0.001). Beaches with >0-5% boulder had more burrows than expected in adjacent habitats and beaches with >5-95%, boulder had fewer burrows than expected in adjacent habitats (X^2 = 34.1, 5 df, P < 0.001). More burrows than expected were located adjacent to beaches with <33% vegetative debris and fewer than expected adjacent to beaches with ≥33-66% or >66% debris (X^2 = 17.3, 2 df, P < 0.001).

The percent slope of the ground between burrows and adjacent beaches was recorded in 1980 and 1981. Slopes ranged from 0-99%. Results showed that more burrows than expected were associated with slopes of 41-80% and fewer than expected with slopes of 0-20% (X^2 = 28.46, 4 df, P < 0.001). Burrow aspect (direction facing the beach) did not show up as being an important criterion in selection of burrow sites by otters (X^2 = 8.92, 7 df, P = 0.258).

Percent shrub cover was estimated, tree numbers counted, and tree dbh's measured in the 126 burrow plots established in 1981. These plots were combined with the 120 randomly selected plots in which no burrows were found during 1981. Analyses were conducted on all 246 plots to determine whether or not any of the recorded vegetative characteristics played a part in otter selection of burrows. Mean values for percent shrub cover and canopy closure were calculated using the midpoint values of the cover classes; >0-5% = 2.5, >5-25% = 15, etc. (Table 12). The means were derived from broad classes (e.g. >25-50%) and therefore no standard errors were calculated for them.

Mean shrub and canopy closure values obtained using 519 plots established along perpendicular transects (the 120 plots used previously

Table 12. Mean shrub and canopy cover (%) for 126 burrow plots and 519 non-burrow plots in Cholmondeley Sound, 1981.

Habitat type		Burrow plots (mean %)						Non-burrow plots (mean %)					
	N	*Vaccinium*	*Menziesia*	Salal	*Rubus*	*Oplopanax*	Canopy Closure	*N*	*Vaccinium*	*Menziesia*	Salal	*Rubus*	*Oplopanax*	Canopy Closure
Old growth high volume	22	38	22	9	3	2	44	126	36	11	6	5	4	29
Old growth low volume	45	37	20	31	2	2	44	114	37	12	43	4	2	35
Second growth	13	38	21	9	2	2	31	96	23	15	9	6	2	41
Clearcut	2	38	2	2	2	2	38	84	22	9	3	37	6	9
Residual beach fringe	9	49	8	2	3	3	46	99	32	13	8	13	4	23
Islands	35	28	16	24	2	2	47							
Totals	126	36	18	20	2	2	44	519	31	12	14	11	4	28

plus the remaining 399 plots) are presented in order to compare the vegetative characteristics occurring in these plots without burrows with those recorded in the 126 plots with burrows (Table 12). The most noticeable differences between the 126 burrow plots and the 519 non-burrow plots show up in the percent cover of *Rubus* and the percent canopy closure; burrow plots contain less *Rubus* cover than non-burrow plots and have a greater amount of canopy closure than non-burrow plots. Note that the two burrows located in clearcut habitat had only 2% *Rubus* cover compared with the 37% average for non-burrow plots in clearcuts. Also, the canopy closure of 38% associated with burrows in clearcuts is larger than the 9% determined for non-burrow plots in clearcuts. Thirty-eight, 35, and 27% of the non-burrow plots established in clearcuts contained light (<33%), medium (≥33-66%), and heavy (>66%) debris on adjacent beaches, respectively. Vegetational debris on the beaches adjacent to the two burrow plots in clearcuts was light (<33%). The mean dbh of the trees measured in the two burrow plots in clearcuts was 17.3 cm compared with a mean of 6.6 cm for trees in non-burrow plots. These differences noted between burrow and non-burrow plots in clearcut habitat suggest that although otters generally tend to avoid using clearcuts, they may use microhabitats within clearcuts which are more typical of mature forests.

All cover classes of *Vaccinium* and rusty menziesia occurred with the number of otter burrows expected (X^2 = 7.61, 5 df, P = 0.18; X^2 = 4.51, 4 df, P = 0.34). Salal cover of >0-5% occurred with fewer burrows than expected (X^2 = 13.77, 4 df, $0.005 < P < 0.01$). Zero to 5% *Rubus* cover occurred with more burrows than expected and >5-100% with fewer than expected ($X^2 = 15.97$, 1 df, $P < 0.001$). More burrows than expected were found with >0-5% *Oplopanax* cover and fewer than expected with *Oplopanax* cover of >5-50% ($X^2 = 7.02$, 1 df, $0.005 < P < 0.01$). Large densities of *Oplopanax* and *Rubus* were common in openings such as those typically found in clearcut habitat. Canopy closures of >25-50% and >75-95% occurred at burrow sites more often than expected and >0-5% closure less often than expected ($X^2 = 21.66$, 5 df, $P = 0.0006$). All 246 plots contained 0-5% *Ribes* cover.

Association of burrows with tree density was tested using a chi-square test. Using breakdowns of 0-3, 4-6, 7-9, etc., trees per plot, no relationship was detected between tree density and the presence of otter burrows (Table 13). Tree dbh's were also analyzed to see if certain sizes of trees were associated with the presence of otter burrows. Otter burrows generally occurred in areas with large trees. Tree dbh classes for hemlock, cedar, and spruce all occurred with burrows in the amount expected (Table 14). Plots with 0-8 cm dbh alders occurred with otter burrows less often than expected and 9-18 cm dbh alders more often than expected. This reflects the presence of older, and thus larger, alders in mature forests and small alders in forest openings. Snags with dbh's of 0-38 cm occurred in association with burrows less often than expected and snags with dbh's of 39-79 cm and 80-160 cm more often than expected. Burrows occurred with mean tree dbh's per plot of 53-109 cm more often than expected and with 0-52 cm less often than expected. The tendency for otters to locate burrows in sites with large trees was further indicated by the fact that plots having 0-1 tree with a dbh greater than 51 cm had fewer burrows than

Table 13. Chi-square values for number of trees and snags occurring in combined 126 burrow and 120 non-burrow plots established in Cholmondeley Sound, 1981.

Species	χ^2	df	*P*
Hemlock	7.01	7	0.43
Cedar	7.15	8	0.52
Spruce	4.88	3	0.18
Alder	4.54	4	0.34
Snags	0.69	2	0.71
Total	8.21	12	0.77

Table 14. Chi-square values for tree and snag dbh categories in 126 burrow and 120 non-burrow plots established in Cholmondeley Sound, 1981.

Species	χ^2	df	*P*
Hemlock	1.94	1	0.163
Cedar	6.59	7	0.473
Spruce	10.29	6	0.113
Alder	5.76	1	0.016
Snag	21.64	2	<0.001
Total	8.88	1	0.003

expected and plots with 2-3 or 4-5 trees with dbh's greater than 51 cm had more burrows than expected ($X^2 = 15.11$, 2 df, $P = 0.0005$). Finally, plots with 0-1 tree with a dbh greater than 76 cm had fewer otter burrows than expected whereas plots with 2-4 trees with diameters greater than 76 cm had more burrows than expected ($X^2 = 5.76$, 1 df, $P = 0.0164$).

At each burrow site, the physical structure (tree, snag, soil) under or in which the burrow was located was recorded. In cases where burrows consisted of cavities under the roots of trees or snags, the dbh of the tree or snag was recorded (Table 15). With the exception of clearcuts, cavities under snags were used as otter burrows in all habitats more often than any other structure. Cavities under hemlock and cedar trees were also commonly used as burrow sites by otters. Three otter burrows were in cavities under spruce trees, all of which were large trees (Table 15). The occurrence of large trees at burrows has been discussed previously and is further indicated by the overall mean dbh value of 85 cm for trees and snags directly associated with burrows.

Burrow cavities beneath alders were not encountered during this study. Harper (1981) reported finding three otter (*L. lutra*) natal dens in riparian habitat along freshwater streams in Scotland. Two of the dens were associated with alder trees having trunk diameters of 2 m and 75 cm. The third den was located in an inaccessible area with willow (*Salix* spp.), about 100 m from a 1.5 m-wide stream.

Melquist and Hornocker (1983) indicated that selection of otter den and resting sites was based on availability and convenience. They found

Table 15. Structures under or in which otter burrows were located in Cholmondeley Sound, 1981.

				$\bar{x}$ dbh		SD	
Habitat type	Structure	N	%	cm	in	cm	in
Old growth high volume	Hemlock	4	18	52.7	20.7	4.8	1.9
	Cedar	3	14	115.1	45.3	6.4	2.5
	Snag	11	50	94.2	37.1	38.1	14.9
	Soil	3	14	---	---	---	---
	Deadfall	1	4	198.1	78.0	---	---
Old growth low volume	Hemlock	8	18	65.0	25.6	22.5	8.9
	Cedar	11	24	111.3	43.8	56.2	22.1
	Spruce	3	7	105.0	41.3	27.1	10.7
	Snag	17	38	80.5	31.7	36.0	14.2
	Soil	5	11	---	---	---	---
	Deadfall	1	2	93.9	37.0	---	---
Second growth	Hemlock	1	8	33.0	13.0	---	---
	Cedar	3	23	62.6	24.7	23.0	9.1
	Snag	9	69	75.9	29.9	47.4	18.6
Clearcut	Soil	1	50	---	---	---	---
	Deadfall	1	50	81.3	32.0	---	---
Residual beach fringe	Hemlock	2	22	45.7	18.0	14.4	5.6
	Cedar	1	11	142.2	56.0	---	---
	Snag	5	55	74.2	29.2	32.5	12.8
	Soil	1	11	---	---	---	---
Island	Hemlock	7	20	58.8	23.1	26.2	10.3
	Cedar	7	20	128.1	50.4	29.9	11.8
	Snag	18	51	86.2	33.9	24.8	9.8
	Soil	3	9	---	---	---	---
Total	Hemlock	22	17	57.6	22.7	21.1	8.3
	Cedar	25	20	111.9	44.0	44.8	17.6
	Spruce	3	2	105.0	41.3	27.2	10.7
	Snag	60	48	82.9	32.6	34.7	13.6
	Soil	13	10	---	---	---	---
	Deadfall	3	2	124.5	49.0	64.1	25.2
	All trees/ snags[a]	110	87	85.0	33.5	39.0	15.4

[a] Does not include deadfalls.

that active and abandoned beaver bank dens and lodges were used more often by instrumented otters in Idaho than any other kind of resting site. No beaver structures were encountered along the coastal region of Cholmondeley Sound and otter use of beaver dens and lodges in freshwater areas was never observed.

Presence or absence of above-ground freshwater at otter burrows was recorded. Of the 126 burrows characterized, 72% had no apparent freshwater present although freshwater could have been present in below-ground cavities. Six percent were within 30 m of lentic pools, 21% within 30 m of streams, and one burrow, used by adult female 04, was located within 2 m of a lake.

Otters probably spend most of their resting time inside burrows due to the great amount of rainfall. However, on warm, dry days they may lie outside burrows under the tree canopy. Concave, compacted depressions were observed within 1-2 m of 56% of the burrows. These depressions were probably formed by otters rolling and scratching and may have been used as resting locations (i.e. external beds).

Eighty-four percent of the characterized burrows had more than one opening through which otters entered and exited. Sixteen percent had only one visible opening.

Sixty-three otter burrows were encountered while transects established parallel to the beach were being run and 25 while I walked around islands. Distances between consecutive burrows within transects or on islands were measured in order to determine burrow densities within the different habitat types (Table 16). Burrows were also mapped to show their spatial distributions (Fig. 2). Old growth low volume

Table 16. Densities of river otter burrows in six habitat types identified in Cholmondeley Sound, 1981.

Habitat type	*N* Burrows	Total length of transects (km)	Burrow density	Mean distance between burrows (m)	SD
Old growth high volume	16	3.2	1 burrow/ 200 m	138.4	139.6
Old growth low volume	27	3.2	1 burrow/ 118 m	100.0	140.2
Second growth	11	1.6	1 burrow/ 145 m	101.3	159.9
Clearcut	2	1.6	1 burrow/ 800 m	284.4[a]	---
Residual beach fringe	7	1.2	1 burrow/ 171 m	144.4	178.7
Island	25	4.0	1 burrow/ 160 m	142.8	155.1
Total	88	14.8	1 burrow/ 168 m	125.7	148.2

[a] Actual distance between two burrows.

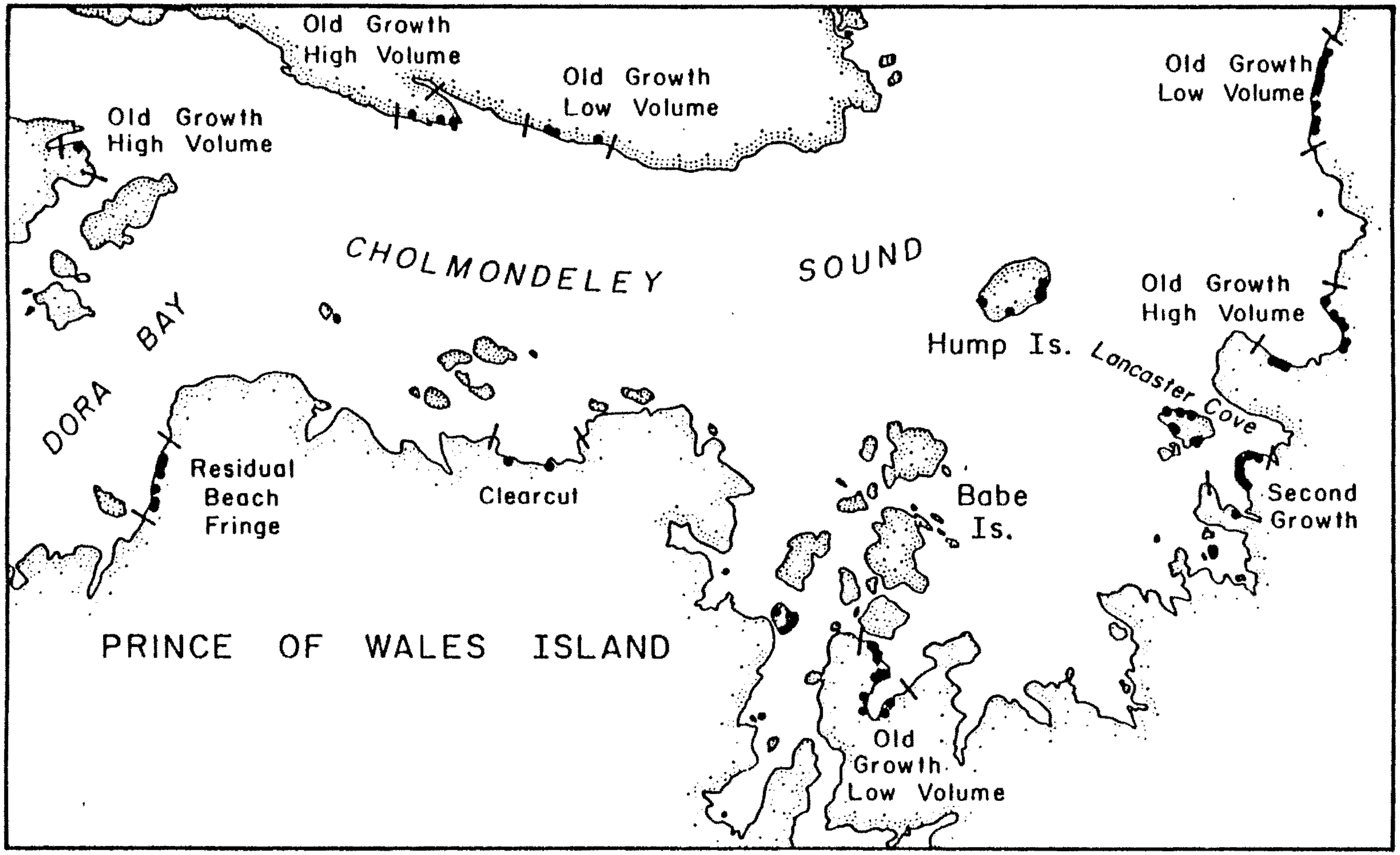

Fig. 2. Distribution of river otter burrows (closed circles) along surveyed segments of coast (indicated with slashes) in Cholmondeley Sound, 1981.

habitat contained the highest density of otter burrows followed by second growth, islands, residual beach fringe, old growth high volume, and clearcuts, respectively. The overall mean distance between burrows was 125.7 m. This was substantially less than the mean distance of 1,160 m observed by Kruuk and Hewson (1978) for a population of river otters (*L. lutra*) along the coast of Scotland. Kruuk and Hewson (1978) reported finding many places along the coast of their study area which appeared to be as suitable for otter burrows as those actually used. It appeared to them that there was some spacing mechanism and they suggested territoriality. They went on to report, based on observations of feeding otters, that capturing prey was not always particularly easy for otters and that defense of limited resources may have been responsible for the observed spacing of burrows. Similar to these findings, several places throughout the Cholmondeley Sound study area which did not have burrows appeared as well suited for resting sites as areas which had burrows. If, as suggested by Kruuk and Hewson (1978), spacing is a function of available resources, the higher burrow density in Cholmondeley Sound may reflect a greater abundance and/or more easily caught prey in this coastal area than Kruuk and Hewson (1978) observed along their coastal study area in Scotland. However, even if resources are comparatively more abundant per area in Cholmondeley Sound, the fact that some unused cavities existed suggests that there are, nonetheless, finite resources available which must be divided among the otter population. Detailed studies are needed to understand spatial distributions of natural cavities used by otters and the relationship between this utilization and the abundance and availability of marine resources.

SUMMARY

River otters avoided 5-20 year old clearcuts. Old growth high volume, old growth low volume, 60-70 year old second growth, and residual beach fringe habitats were used in proportion to their availability. Avoidance of clearcuts was probably due, in part, to the dense shrub growth which spreads quickly after removal of over-story vegetation and to the presence of slash resulting from logging. The fact that 5-20 year old clearcuts were avoided while 60-70 year old second growth stands were used as expected suggests that there may be a stage in the development of regenerating stands where the habitat once again becomes suitable to otters. This could not be determined in this study because the second growth stands which were sampled resulted from fires and therefore were devoid of slash.

Aspect and ground slope of transects had no noticeable effect on otter use of terrestrial habitats. River otters preferred habitats adjacent to convex (point) shorelines with short intertidal lengths consisting predominantly of bedrock substrate. The amount of vegetative debris on beaches was negatively correlated with abundance of otter signs observed on transects. Otter signs were encountered more often than expected in microhabitats having relatively large (i.e. >51 cm) trees and/or snags, >50% canopy closure, and >0-5% *Rubus* cover.

Radio-telemetry was used to determine selection or avoidance of habitat types by radio-tagged otters. Adult male 01 used old growth high volume, old growth low volume, residual beach fringe, and island habitats in the amount expected; however, clearcut and second growth habitats within his home range were used significantly less than expected; he was never located in clearcut habitat. Yearling male 03 used the four habitat types within his home range as expected; these were old growth high volume, old growth low volume, second growth, and islands.

One hundred forty river otter burrows were characterized (14 in 1980, 126 in 1981). Burrows were found more often than expected adjacent to convex shorelines with short intertidal lengths consisting predominantly of bedrock. Aspect did not appear to influence burrow selection by otters; however, areas with ground slopes of 41-80% were used more than expected as burrow sites. Burrows were located at distances of 0.9-22.9 m from the beach and were usually not associated with freshwater.

In general, otter burrows were associated with areas having >0-5% *Rubus* cover and >25% canopy closure. Burrows found in clearcut habitat had an average of 2% *Rubus* cover, 38% canopy closure, and a mean tree dbh of 17.3 cm compared with an average of 37% *Rubus* cover, 9% canopy closure, and a mean tree dbh of 6.6 cm in clearcut areas where otter burrows were not found.

Cavities under snags were used as burrows more often than any other structures. Cavities under hemlock and cedar trees were also used as otter burrows. The mean dbh of all the trees and snags associated with cavities used as burrows was 85 cm (33.5 in.).

Burrow density was highest in old growth low volume habitat and decreased progressively in second growth, island, residual beach fringe, old growth high volume, and clearcut habitats, respectively. The mean distance between otter burrows in all habitats was 125.7 m.

MOVEMENT PATTERNS AND HOME RANGE

Information concerning river otter movements was largely restricted to anecdotal observations during the first half of this century. Reported observations indicated the swimming prowess of otters (Scott 1939, Scheffer 1953) and the speed of otters on land (Lang 1924, Severinghaus and Tanck 1948). Studies of daily and seasonal movements and home range sizes were not reported during this time period.

Beginning in the 1960's, otter tracks and signs were used as a means of quantitatively estimating movement patterns and home range sizes of otters living in freshwater habitats (Erlinge 1967*b*). Difficulties associated with live-trapping river otters made mark-recapture techniques impractical. In the mid 1970's technical advances in biotelemetry made it practical to construct radio-transmitters which could be surgically implanted in the peritoneal cavities of otters. Previous attempts to outfit otters with variously designed external transmitter collars had resulted in otters slipping out of the collars, irritation to otter's necks, and/or transmitter failure (Melquist and Hornocker 1979).

The development of implantable transmitters has made it possible to conduct field research on movement patterns and home range sizes of free-ranging river otters (Reid 1981, Foy 1982, Melquist and Hornocker 1983, Woolington, in prep.). Data presented in this section of the thesis represent the first information available on movement patterns and home range sizes of river otters living in a marine environment in North America.

MATERIALS AND METHODS

The timing and extent of otter movements in this study were estimated from information collected by monitoring radio-tagged otters and from observations of otters. Minimum distances traveled in 24 hours were recorded for adult male 01 and yearling male 03 as the straight-line distance between radio-locations obtained on consecutive days. Males 01 and 03 were often located three or four times during a single day; never together. These males usually remained at one site for entire daytime periods but did not necessarily return to the same site each day. In rare cases where more than one site was used by these individuals during a single day, the site at which most of their time was spent was used in the analysis of distances traveled in 24-hour periods.

Seasonal changes in the minimum daily movements of males 01 and 03 were examined using *t* tests. Seasons were defined in this study as: winter (Dec-Feb), spring (March-May), summer (June-Aug), and fall (Sept-Nov).

Male 01 was monitored during three 24-hour periods and five diurnal periods. The use by otters of the shoreline and adjacent narrow strip of forested habitat (*see* Habitat Use section, pg. 26) made it possible to follow male 01 with a boat. The total distance traveled during each of the eight continuously monitored periods were measured on a map by tracing the actual route of travel with a calibrated map wheel. Localized movements by radio-tagged otters in the area of a single site were identified from changes in the volume of the transmitted signal.

When radio-tagged and unmarked otters were observed moving on the study area, the time at which they were sighted was recorded along with the date, tide level, and location. When unmarked otters were sighted, it was usually impossible to determine the nature of their activities. Therefore, they were simply recorded as being active. Activities of radio-tagged otters were recorded as moving on land or moving in water, depending on where they were sighted. When radio-tagged otters were determined to be inactive they were recorded as resting. These data were used to derive an estimate of the activity patterns of otters in this area.

Home ranges used by radio-tagged otters were delineated using the minimum area method of Mohr (1947) and were measured using a planimeter. All outermost locations were used in defining home ranges, regardless of the number of visits to the sites. Also, the total length of shoreline within each otter's home range was measured and reported. This facilitated direct comparisons with findings from other studies in which home ranges were based on total shoreline length (Melquist and Hornocker 1983, Woolington, in prep.). Extended use areas, which were areas where radio-tagged otters were located a minimum of five times during the study, were plotted for males 01 and 03.

RESULTS AND DISCUSSION

MOVEMENTS

Travel routes of otters in this study generally followed the shoreline; however, otters would occasionally take shortcuts of approximately 100-200 m across peninsulas (Fig 3, 17-18 June). Foraging often appeared to occur in connection with movements along the shoreline, but otters were sometimes observed swimming between adjacent land areas without attempting to capture prey. The absence of pelagic prey species from otter scats (*see* Feeding Habits section, pg. 119) indicates otters probably do not forage in areas of deep, open water. It is interesting to note that they may swim between land areas separated by as much as 3 km of open water with depths up to 240 m. Male 01 was observed swimming between Babe Island and Hump Island (Fig. 1, pg. 6) without feeding. Upon reaching the shallow water off the southeast shore of Hump Island, however, he began foraging and was successful in capturing a sculpin which he carried into the forest and partially consumed. Forty-five minutes later he re-entered the water, swam without diving to Lancaster Island and once there, began foraging in the shallow waters off the northwest end of the island.

The presence of otter signs on or near lake shores and along the banks of effluent streams flowing into marine estuaries suggested that otters moved from coastal areas into freshwater habitats. On one occasion in July, adult female 04 was located in a burrow within 2 m of the edge of a freshwater lake, approximately 200 m inland. This was the

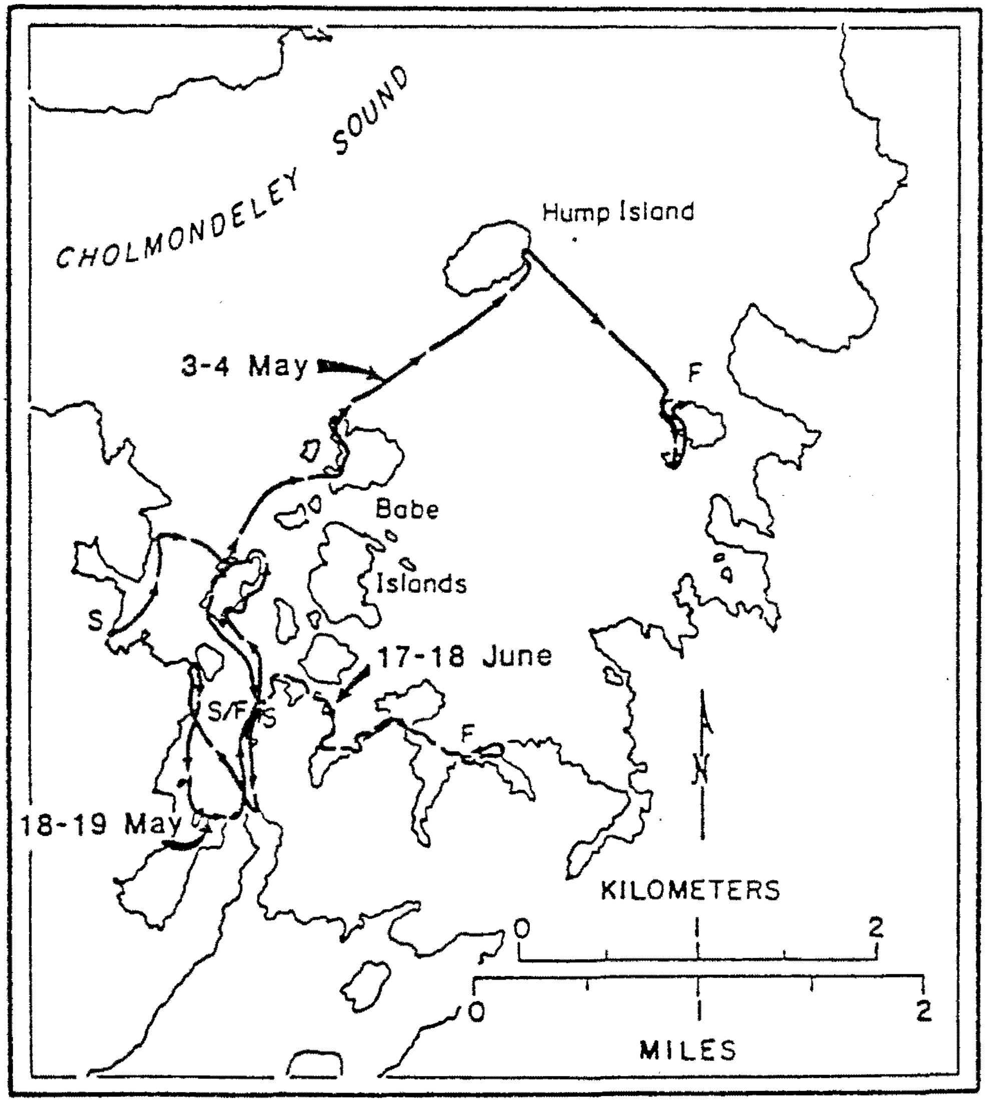

Fig. 3. Travel routes of adult male 01 during three 24-hour monitoring sessions: 3-4 May, 18-19 May, and 17-18 June, 1981. Starting points are indicated with an S and finishing points with an F.

only observation of a radio-tagged otter using freshwater habitat in this study. In contrast, Home (1977) reported observing one group of otters traveling back and forth between the marine coast and inland freshwater habitats; he also reported that another group spent more time along a 6 km-long river and associated lake system than in or near the adjacent marine system. Kruuk and Hewson (1978) reported that otters (*L. lutra*) along the northwest coast of Scotland rarely moved inland.

The distances traveled by males 01 and 03 during 24-hour periods were estimated by measuring the straight-line distances between their consecutive-day locations (Table 17, Appendix E). An adequate number of locations was not obtained for females 02 and 04 to allow their inclusion in this analysis. Distance measurements were conservative; in extreme cases, otters returned to the same location where they had spent the previous day after moving considerable distances during the night. This was observed, for example, for adult male 01 on the second of three 24-hour observation sessions which was conducted on 18 May to 19 May 1981 (Fig. 3, Table 18). During this 24-hour period, he traveled an actual distance of approximately 7 km; however, since he returned to the starting location his distance traveled would have been recorded as zero using the distance between consecutive-day locations. For this reason, the reported estimates of distances traveled in 24-hour periods should be considered low.

Changes in distances traveled between spring, summer, and fall were recorded for adult male 01 and between summer and fall for yearling male 03 (Table 17). Male 01 traveled significantly longer distances in 24-hour periods during the fall than during the spring (*t* test,

Table 17. Seasonal distances (km) between consecutive-day locations of adult male 01 and yearling male 03, 1981. Distances were recorded as the straight line measurements between consecutive-day locations.

Individual	Season	*N*	$\bar{x}$	SD	95% CI	Range (km)
Adult male 01	Spring (Mar-May)	28	1.07	1.24	0.61-1.53	0.0 - 4.0
	Summer (June-Aug)	27	1.55	1.18	1.10-1.99	0.0 - 3.4
	Fall (Sept-Nov)	50	2.07	1.30	1.17-2.43	0.0 - 5.1
	Summer + Fall	77	1.89	1.28	1.61-2.18	0.0 - 5.1
	Spring, Summer + Fall	105	1.67	1.31	1.42-1.92	0.0 - 5.1
Yearling male 03	Summer (June-Aug)	5	0.64[a]	0.54	0.17-1.11	0.4 - 1.6
	Fall (Sept-Nov)	11	2.57	2.04	1.37-3.77	0.0 - 4.6
	Summer + Fall	16	1.97	1.93	1.03-2.87	0.0 - 4.6

[a] This value was derived from five separate consecutive-day locations obtained within two weeks after the release of male 03. It is probably low since otters tended to move relatively little up to two weeks after being released.

Table 18. Distances traveled by adult male 01 during three 24-hour monitoring sessions, 1981. Total distances traveled were determined by measuring the actual travel routes. Point to point distances were recorded as the straight line measurement between the first and last locations of the 24-hour sessions.

Session	Date	Total distance (km)	Point to point distance (km)
1	3-4 May	6.4	4.0
2	18-19 May	7.0	0.0
3	17-18 June	4.0	1.6
		$\bar{x} = 5.8$	$\bar{x} = 1.9$

$P < 0.05$). No significant differences were observed between spring and summer or summer and fall. Male 03 traveled significantly further in 24-hour periods during the fall than during the summer (*t* test, $P < 0.05$). The estimated summer mean of 0.64 km is probably unrealistically small since all five consecutive-day locations recorded during the summer for this individual were obtained within a week after he was released; radio-tagged otters tended to remain within a relatively small area for up to two weeks immediately after being set free.

Summer, fall, and combined summer and fall distances traveled by males 01 and 03 were compared (Table 17). Adult male 01 traveled significantly further during summer than did yearling male 03 (*t* test, $P < 0.05$). But, as noted above, this was probably the result of a lower than normal summer estimate for male 03. There was no significant difference between the fall or combined summer and fall distances when compared between individuals.

DIEL PATTERNS

Most data on diel patterns were obtained by monitoring male 01. Limited data were also collected by monitoring female 02 and male 03. Female 02 was observed in the water during daytime hours nearly as often as she was located at resting sites (Fig. 4). Male 01 was found to be primarily nocturnal (Fig. 5). Male 03, like male 01, was located most often at resting (burrow) sites between 0900 and 1900 hours (Fig. 4). Although usually resting during this time period, males 01 and 03 were

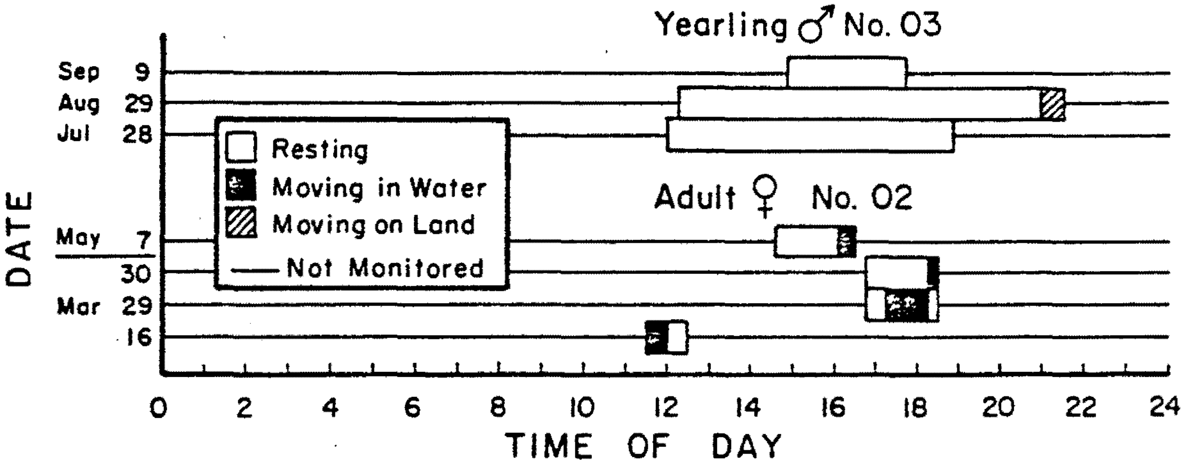

Fig. 4. Diel activity patterns of adult female 02 (6.5 hours of monitoring), and yearling male 03 (13.0 hours of monitoring), in Cholmondeley Sound, 1981.

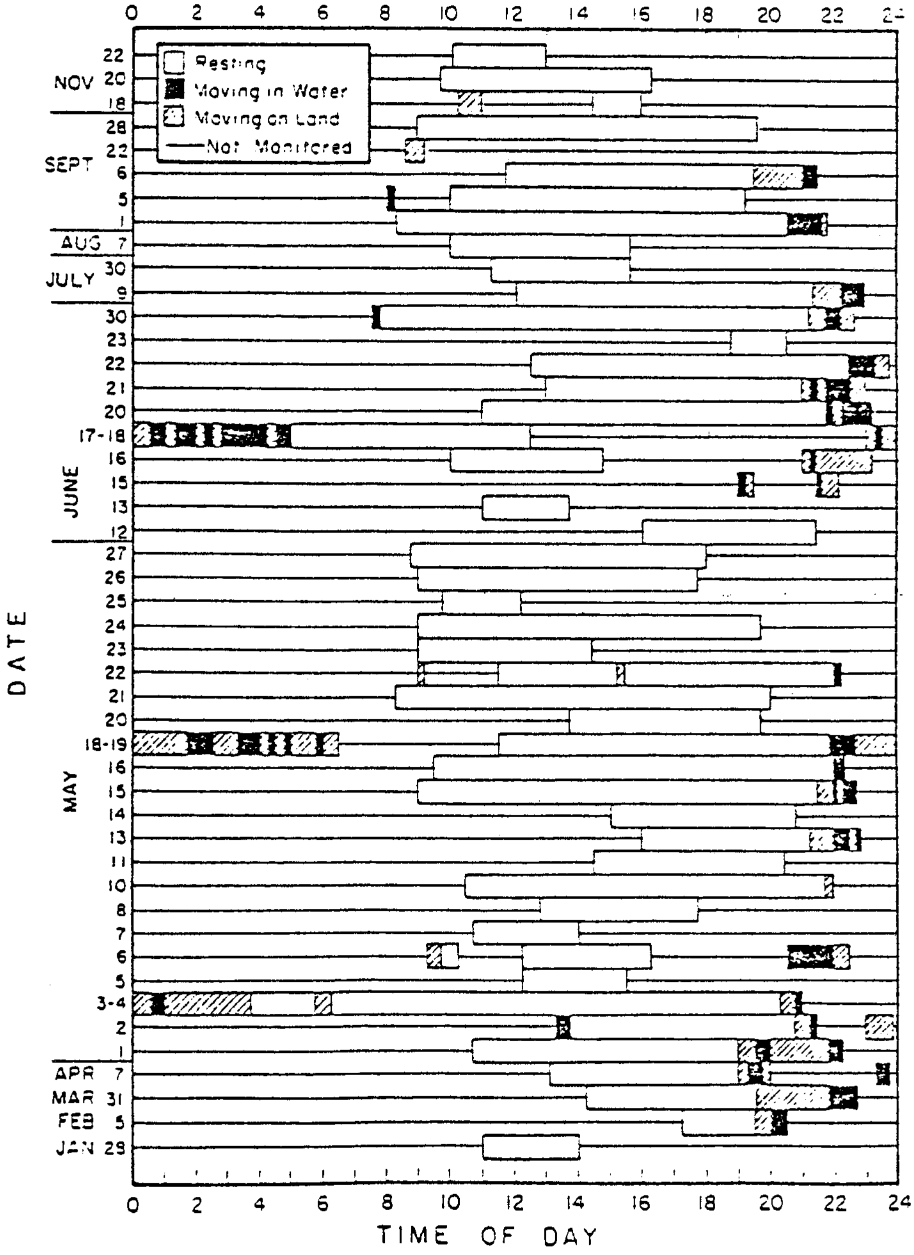

Fig. 5. Diel activity patterns of adult male 01. Based on 385.5 hours of monitoring in Cholmondeley Sound, 1981.

occasionally detected moving at or between sites. Likewise, unmarked otters were sometimes sighted during the daytime in the water and on land (Appendices F, G). Since it was not usually possible to sight otters at night, there was an obvious bias towards daytime sightings. Further bias may have existed as a result of unequal daytime hours spent boating on the study area.

Otters occupying riverine systems in Idaho were found to be significantly more nocturnal in spring, summer, and fall than in winter (Melquist and Hornocker 1983). A wild-caught, captive, adult female otter (*L. lutra*) was almost entirely nocturnal when she first came into captivity (Harper and Jenkins 1981). When she was put together with a hand-reared male she became much more diurnal. Jenkins (1980) found that when few otters were present in marine inlets in Scotland they were predominantly nocturnal. When numerous, the otters, especially single animals, were more diurnal.

Diurnal movements of radio-tagged otters appeared to be associated with feeding or drinking whereas nocturnal movements, in addition to being tied to these activities, appeared to be conjoint with searching for signs left by other otters and marking behavior. For example, female 02 was once observed foraging with one other otter during late afternoon. The otters had been inactive at a burrow site prior to this activity. After an hour of feeding the two otters were apparently satiated and returned to the burrow where they again became inactive. Male 01 was twice located in burrows during the daytime which he left long enough to move approximately 20 and 300 m in order to drink water from freshwater streams. Another time he was detected moving through the forest during early afternoon. A survey of the area later revealed the remains of a sculpin carcass which had been recently killed and consumed. It appeared that male 01 had caught the fish, carried it into the forest and eaten it. Subsequent to this he was located at a burrow site where he remained for the duration of the daytime.

Movements at night involved more extensive travel in water by male 01 than did movements during the daytime. In addition, the amount of time spent moving around on land at haul-out sites (use areas) was greater during the nighttime than during the daytime (Fig. 5). These extended periods of localized terrestrial movements were probably related to searching for mark piles left by other otters and marking behavior.

Intensive monitoring of other sex and age classes of otters inhabiting coastal environments is needed in order to determine whether or not the patterns shown by male 01 are typical of otters in general. Nighttime monitoring would be of immense value.

FACTORS INFLUENCING MOVEMENTS

Sanderson (1966) indicated that movement patterns are established and regulated by the density of the species, food supply, reproductive activity, the quality and physiographic arrangement of the habitat, and no doubt many other factors. To identify and discuss every factor would be difficult. In this section of the thesis a few of the possible factors influencing movements by river otters on the Cholmondeley Sound study area are addressed.

Intrinsic Factors

As reported earlier, nocturnal movements by otters in this study were believed to be associated with feeding, searching for mark piles left by other otters, and marking activities. The combination of these three activities probably dictates movements by otters during most of the year on the Cholmondeley Sound study area. Dispersal may also be an important intrinsic factor contributing to otter movements. Although it was not possible to collect definitive data concerning movements resulting from intrinsic cues, otters are curious animals and it is possible that a certain amount of movement is due to an exploratory urge (Melquist and Hornocker 1983).

In addition to searching for signs left by other otters, otters possess an innate desire to leave their mark, both urine and excrement, at use areas. Liers (1951) reported that when several otters travel together each one tries to be the last to leave its mark before moving on. This may at least partially account for the tendancy of otters to revisit use areas within their home ranges. In this way they could determine whether or not other otters had visited specific sites during their absence and then leave their own mark to advertise their presence before departing. Erlinge (1977) found that stoats (*Mustela erminea*) regularly patrolled the boundaries of their ranges, covering some parts every day. Scent-marking was associated with boundary patrols and neighboring individuals were apparently aware of the boundaries and usually avoided close contact. Similar marking behavior and avoidance have been reported for mountain lions (Hornocker 1969) and bobcats (Bailey 1974).

With the exception of female 04, for whom an insufficient number of locations were obtained prior to her death, all radio-tagged otters in this study visited at least one site more than once (Table 19). These were sites where otters spent extended periods of time during the daytime.

Prey Abundance and Availability

Prey abundance and availability influences otter movements to some extent. During the fall, male 01 was observed repeatedly using a burrow site located within 100 m of a freshwater stream in which pink and chum salmon were spawning. Otter tracks were observed along the stream bank, and scats were found which contained salmon roe, indicating seasonal use of these fish species by otters (*see* Feeding Habits section, pg. 120). Similarly, Melquist and Hornocker (1983) observed otters remaining for up to 40 continuous days in areas where spawning kokanee salmon (*Oncorhynchus nerka*) were abundant. When the fish became scarce, otters returned to a pattern of frequent movement.

Shells of abalone, plates of chitons, and exoskeletons of sea urchins were occasionally encountered in local abundance at otter use areas in this study. Islands tended to have considerably more abalone shells on them than did the adjacent mainland regions of the study area, reflecting a greater abundance of these mollusks in the intertidal zones around islands. Chiton and urchin remains, although found on both islands and mainland regions in similar frequencies, were aggregated,

Table 19. Use of specific sites by radio-tagged otters and the average number of radio-locations made per site on the Cholmondeley Sound area, 1981. Based on sites where otters spent extended periods of time.

Individual	*N* locations	No. of sites visited[a]	No. of locations at site[b]	Avg. no. of locations per site[c]
Adult male 01	130	17	1	3.17
		3	2	
		5	3	
		7	4	
		1	5	
		4	6	
		2	7	
		1	9	
		1	12	
Adult female 02	14	8	1	1.40
		1	2	
		1	4	
Yearling male 03	28	11	1	1.65
		3	2	
		2	3	
		1	5	

[a,b] Columns should be read together. For example, 17 sites, each used 1 time.

[c] Average number of locations per site = $\frac{\text{total no. of locations}}{\text{total no. of sites visted}}$.

suggesting local occurrences of these invertebrates. It appeared that the abundance of various prey species was affected both spatially as well as seasonally. Being opportunistic, otters probably move in response to local changes in prey densities or availability, resulting in a diversification of prey items consumed (*see* Feeding Habits section pg. 119)

Reproductive Activity

Seasonal changes in the frequency of otter movements were determined by comparing the number of otters sightings made during each month (Fig. 6). The amount of time spent boating on the study area was believed to have been roughly equal throughout all months. Opportunities for sighting otters during each month were therefore believed to have been about equal.

The large number of observations made during May coincides with the time of breeding for otters in southeastern Alaska (Solf 1978). Woolington (in prep.) and J. Noll (pers. commun.) reported observing six and two otter matings, respectively, on Baranof Island in southeastern Alaska. All of these occurred between 7 and 31 May. In this study, one probable mating was detected on 20 May 1981.

According to Liers (1951), the urge to travel is particularly strong in otters during the breeding season. The increased frequency of otter observations made during May could therefore represent an increase in the frequency of movements by otters during this month, particularly males. Increased observations during spring could also indicate a shift to more diurnal patterns; however, male 01 remained chiefly nocturnal

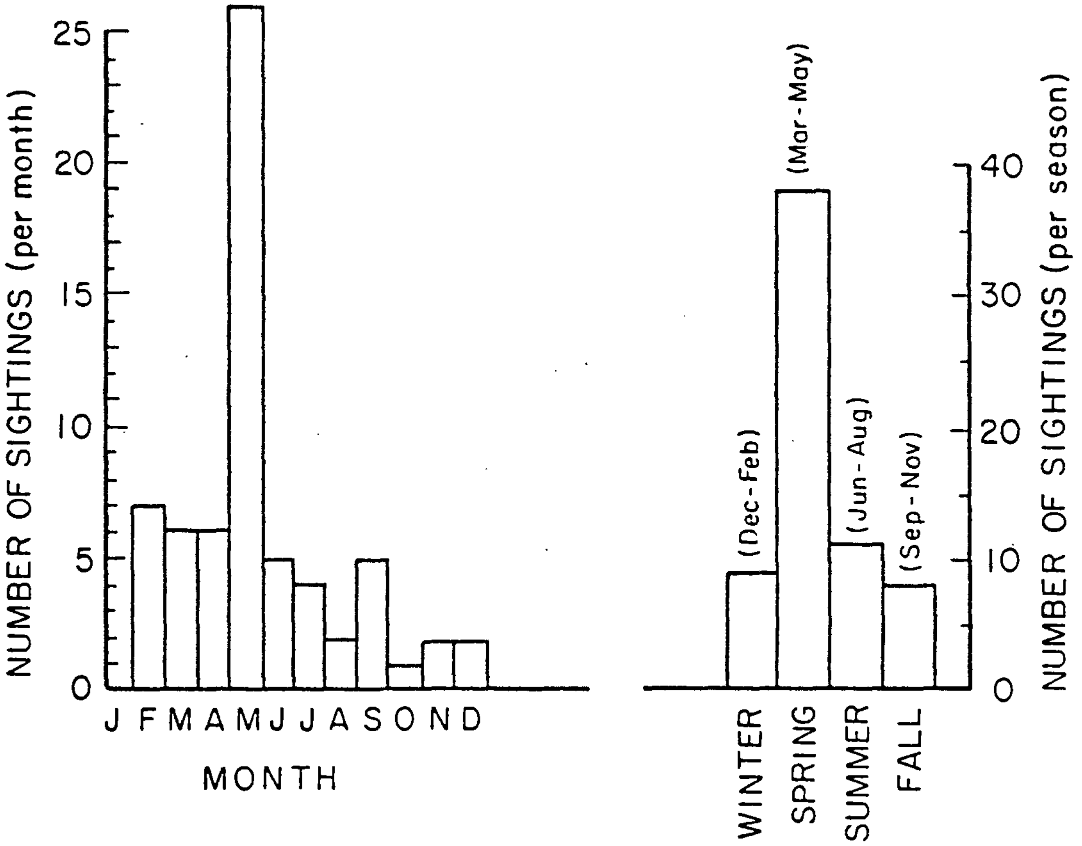

Fig. 6. Number of otter sightings on the Cholmondeley Sound study area during each month and season, 1981.

during spring. Erlinge (1977) reported that juvenile male stoats moved more extensively in spring than in fall and winter. Increased movement activity in males during spring was directed to mating and maintaining territories. Adult male otters (*L. lutra*) in southern Sweden were found to move throughout their home ranges during all seasons with increased movement and activity occurring during the spring (Erlinge 1967). The adult males were observed frequenting all the main otter use areas within their home ranges but showed increased interest in particular parts of these ranges where female otters in estrus were detected. When estrous females were encountered other parts of the home range were temporarily neglected.

The information from these studies along with the increased frequency of otter observations during May and the shorter distances traveled during the spring by adult male 01 in this study may indicate a spring behavior by breeding male otters perhaps best described as "patrolling"; a situation in which adult males reduce the size of the area covered during the spring but move more frequently. Gorman et al. (1978) showed that the occurrence of anal sac secretions is associated with the estrous cycle in European otters (*L. lutra*). Assuming this to be true in *L. canadensis* as well, anal sac secretions would function in alerting adult males to the presence of estrous females. Furthermore, the search for estrous females by breeding males would be simplified because estrous females with newly born pups remain close to the natal den (Melquist and Hornocker 1983). By frequently patrolling small areas within their home ranges where estrous females were detected, males would have an opportunity to breed these females and also determine changes in the condition of females which had not yet come into estrus. At the same time they could continue to mark sites as a means of advertising their presence to other males. The size of the areas patrolled would depend on the abundance and distribution of estrous females. If males attempted to travel too far within their home ranges they would run the risk of having other males move into the temporarily unoccupied areas and breed the estrous females. Therefore, there is probably a maximum "patrollable" area beyond which the benefits of breeding several females gives way to losses of females to other males or simply missing a chance to breed with them during their receptive periods.

Tide

Tide levels at the times of otter observations were determined by interpolating between reported tide levels, using a tide tables book (Anon. 1981) (Fig. 7A). The direction of the tide flow was also recorded: Flood (incoming), ebb (outgoing), or slack (transition between flood and ebb) (Fig. 7B). Slack tide was assigned when observations were made within five minutes before or after low or high tides. No records were kept from which the proportion of time spent boating on the study area during each of the five designated tide level intervals could be determined. Therefore, it could not be determined whether the number of sightings during each interval was a function of movements by otters which were associated with preferred tide levels or whether the differences in the number of sightings resulted from unequal time spent boating on the study area during tide level intervals.

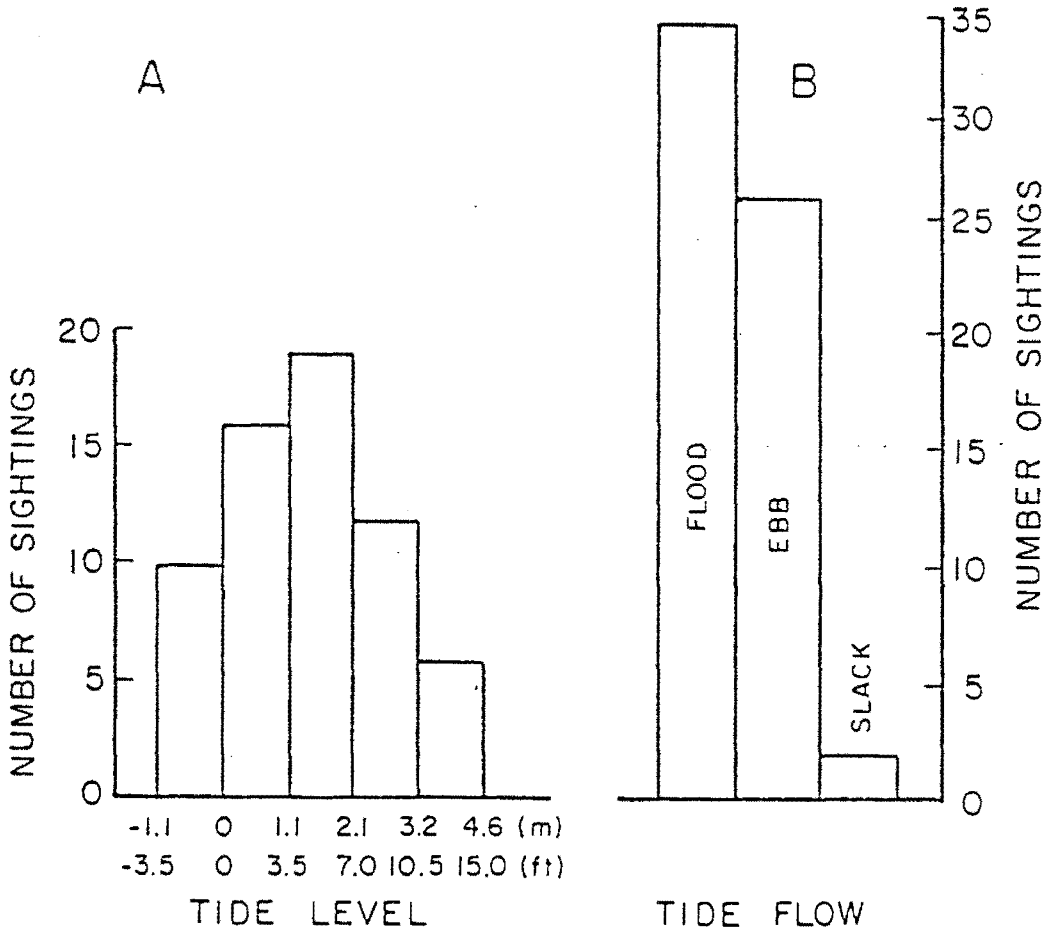

Fig. 7. Number of otter sightings made during various tide levels (A) and number of otter sightings made during flood (incoming), ebb (outgoing), and slack (transition) tides (B). Based on sightings made on the Cholmondeley Sound study area, 1981. Mean low tide = 0.0, other values represent tide levels above and below mean low tide.

The total annual duration of flood and ebb tides in the Ketchikan area has been shown to be within two minutes of each other (Woodworth and Haight 1927). The cyclic duration of flood and ebb tides is approximately six hours. It was assumed that the amount of time spent boating on the study area during flood and ebb tides was about equal. Based on this assumption, the number of observations made during flood and ebb tides should have been about equal if otters were not influenced by tide. A chi-square test of the hypothesis of no differential otter use of tides detected no significant difference between the number of otter observations made during flood and ebb tides ($0.25 > P > 0.21$).

Human Activity

Human activity probably plays a major role in determining movement patterns by otters. Melquist and Hornocker (1983) reported that radio-tagged otters in their study appeared to prefer areas with a minimum of human activity. However, as long as food and shelter were adequate and as long as they were not harassed, otters occupied areas in proximity to human establishments. In the town of Ullapool in northwest Scotland, otters reportedly had to be driven regularly from a moored fishing vessel and were claimed to scavenge in the fish market (Macdonald and Mason 1980). Otters have been known to move about and defecate on boat harbor docks in communities along the coast of southeastern Alaska (L. Johnson, N. Larsen, pers. commun.). In Kelp Bay on Baranof Island, southeastern Alaska, otters were frequently observed traveling or feeding in the coastal waters during the daytime (Woolington, in prep.). Unlike Kelp Bay, Cholmondeley Sound has year-round human inhabitants.

During trapping seasons (Dec-Feb) frequent attempts are made to shoot otters sighted in Cholmondeley Sound. At other times of the year the local inhabitants spend extensive periods of time boating on the area. Human activities include hunting for deer, bear, and waterfowl, fishing, exploring, and occasional tree cutting. As a result of harassment during trapping seasons, otters in Cholmondeley probably associate the sound of boat motors with danger. If so, the sound of motors may induce them to seek safety in the cover of the forested habitat. Otter pups observed in this and Woolington's (in prep.) study were much slower to respond to approaching boats than were accompanying adults. The association of danger with human activity may also vary among adult otters. Woolington (in prep.) observed that some adults were much more cautious of human activity than others; some fleeing instantly and others apparently little more than mildy curious. P. Gipson (pers. commun.) reported observing three otters while boating on a slough off the Tanana River, south of Nenana, Alaska. The otters remained in the area for more than six minutes and one of the otters swam to within 5 m of his boat. This variability in fear of humans is probably related to the nature of previous encounters with humans.

HOME RANGES

Home ranges were delineated for the four radio-tagged otters (Fig. 8). Sizes of home ranges and the total length of shoreline within each home range were measured for all otters except female 04 (Table 20). Elliptical home-range models were not applied because it could not be shown that the otters used their environment in a bivariate normal

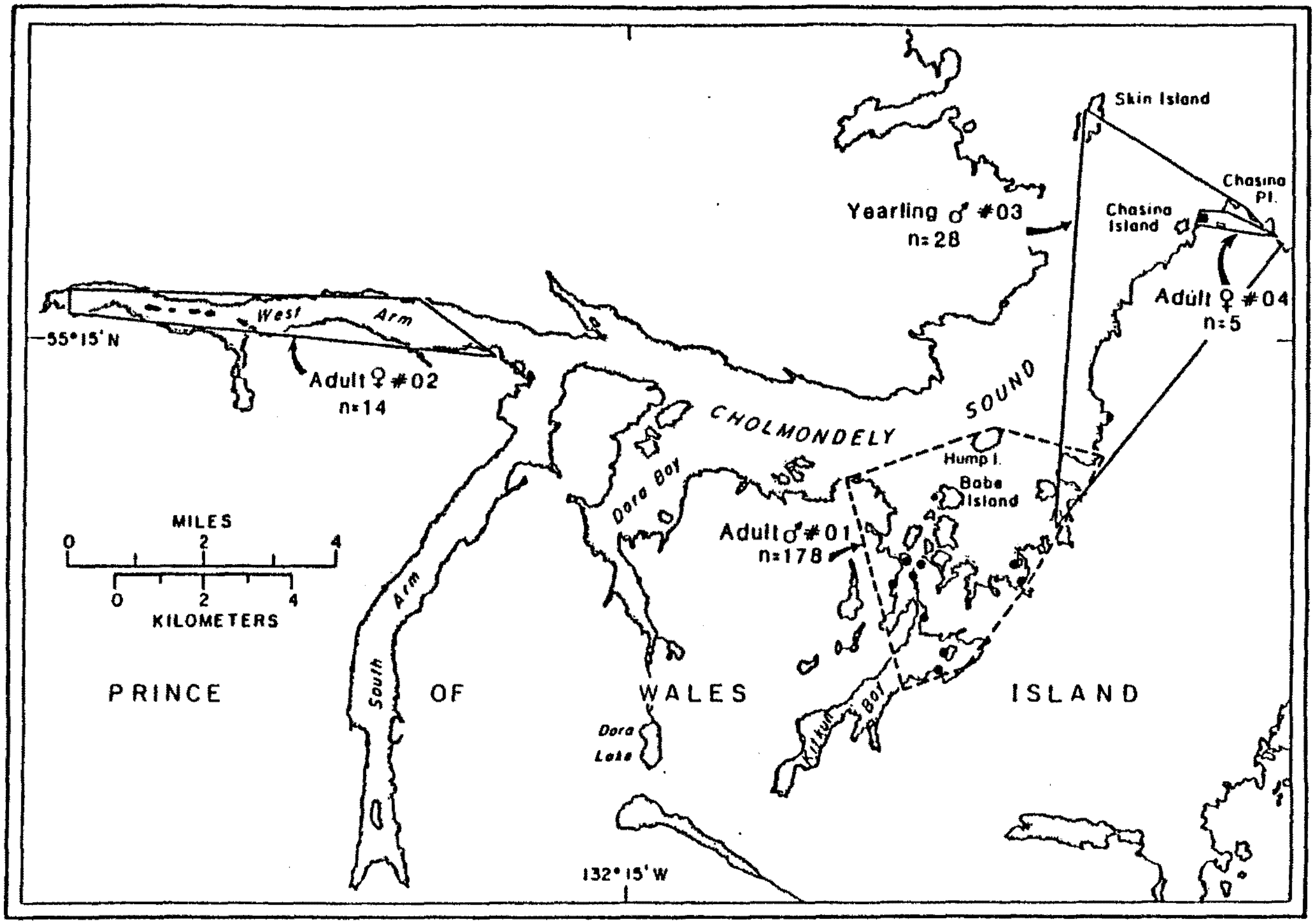

Fig. 8. Home ranges of radio-tagged otters, 1981. Extended use areas were areas where males 01 and 03 were located a minimum of five times and are indicated by closed circles. The extended use area of male 03 is within the area used earlier by female 04. Female 04 died; the area outlined for her does not constitute her entire home range.

Table 20. Home range sizes and total shoreline lengths within home ranges of radio-tagged otters in Cholmondeley Sound, 1981.

Individual	*N* locations	Total area (km^2)	Total shoreline length (km)
Adult male			
01	178	20.99	39.9
Adult female			
02	14	8.96	21.7
Yearling male			
03	28	24.83	19.0

fashion (Smith 1983). The principle of linearity of home-range was shown to apply to several species of small rodents (Stumpf and Mohr 1962) as well as to mink (Mitchell 1961, Hatler 1976). Mink living along the coast of southeastern Alaska concentrate the majority of their activity in a narrow (usually < 20 m) band of forested habitat juxtaposed to the beach and in the waters of the intertidal zone (Johnson, in prep.); river otters appear to do the same.

Home range was determined for male 01 from a total of 178 radio-locations; 41 sites (Fig. 8). These included 130 locations at sites where he spent daytime hours and 48 additional locations at sites which he visited briefly during day and nighttime movements. The home range of yearling male 03 was determined from 28 radio-locations; 17 sites, and the home range of female 02 from 14 radio-locations; 10 sites. Male 03's home range included the area used by adult female 04 (Fig. 8). However, male 03 was not located in the area used by female 04 until approximately one month after she died.

The home ranges of males 01 and 03 overlapped slightly (Fig. 8). Further indications of home range overlap between otters came from observations of unmarked otters within the home ranges of radio-tagged otters. It was determined that at least part of the home range used by adult female 02 (Fig. 8) was also used by another adult female which contained three fetuses at the time of her death in March 1981. Adult male 01 was periodically sighted together with six other otters from June through September 1981. These otters were observed feeding, traveling, and resting together. Solf (1978) indicated that groups of bachelor male otters usually consist of fewer than 10 individuals. This fact plus the similarity in body size of the seven otters suggests that this group was made up of bachelor males. Melquist and Hornocker (1983) observed extensive overlap in river otter home ranges in Idaho; male home ranges overlapped each other considerably as did female home ranges. The fact that otters often occurred at the same activity centers without associating with each other led Melquist and Hornocker (1983) to suggest that otters may have a "personal space" (Marler and Hamilton 1966), which is a space around the otter within which they ordinarily do not allow the approach of other individuals. Fisler (1969) classified this as "personal space dispersion", whereby the individual and its current location are defended without reference to spatial boundaries.

The home range of juvenile male 03 was slightly larger in area than adult male 01's (Table 20). However, the amount of open water within the home range of adult male 01 was less, and the amount of shoreline greater than within male 03's home range. Therefore, male 01 had more shallow water foraging areas and more available potential resting sites.

Seasonal changes in home range size were determined for adult male 01 (Fig 9, Table 21). The area used during the winter was derived from only six locations and is probably not a true representation of the total area used during this season. Although largest during the summer, home range size was similar during spring, summer, and fall (Table 21). Melquist and Hornocker (1983) recorded locations for one yearling male during all seasons. The home range was largest during winter with similar sized ranges used during spring, summer, and fall. They noted seasonal variability among and between individuals. Erlinge (1967*b*)

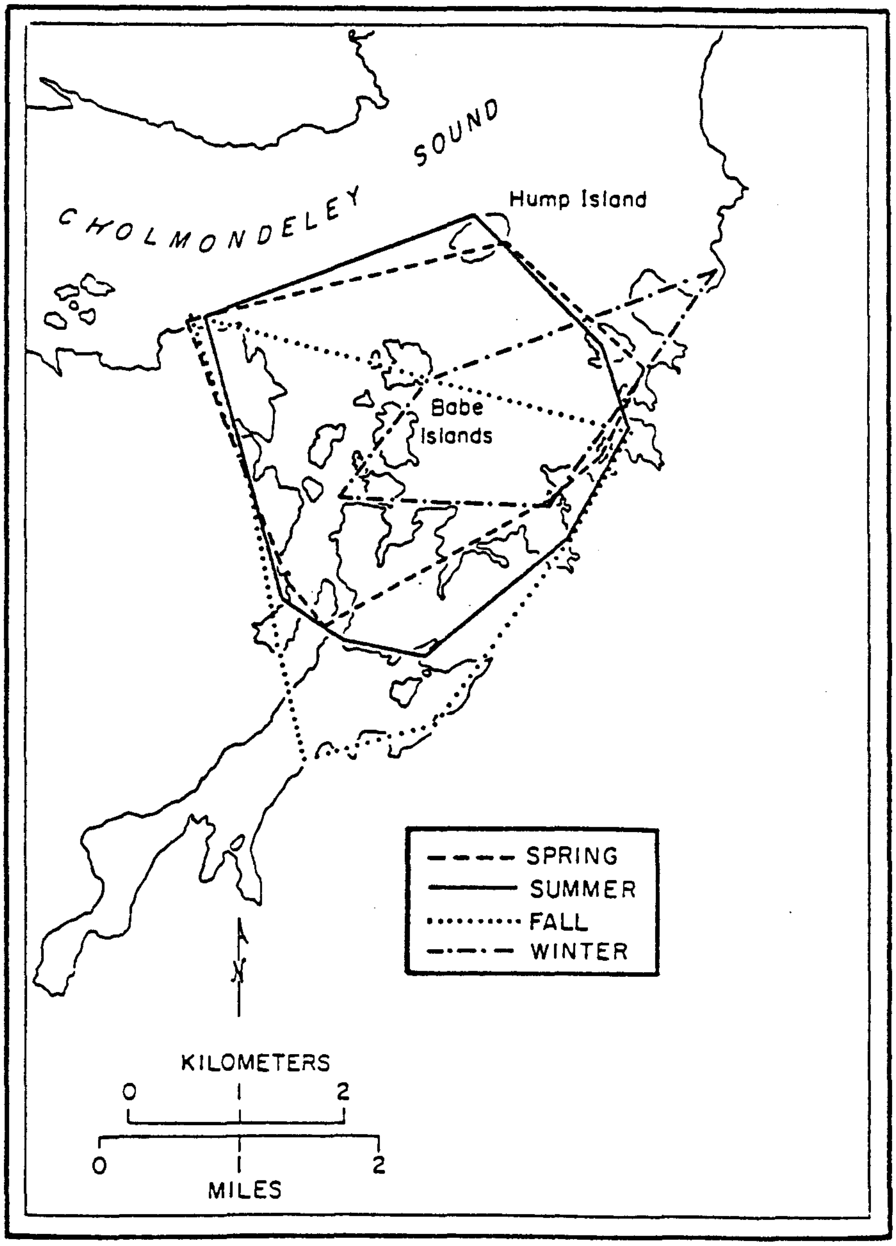

Fig. 9. Seasonal changes in home range size for adult male 01, 1981. Spring (N=47), summer (N=64), fall (N=61), and winter (N=6).

Table 21. Seasonal changes in the home range size and amount of shoreline within the home range of adult male 01, 1981.

Season	*N* locations	Area (km^2)	Shoreline length (km)
Winter	6	4.68	7.2
Spring	47	13.08	23.7
Summer	64	15.22	29.3
Fall	61	12.64	30.1

reported that the sizes of areas traveled by male otters (*L. lutra*) were extremely variable.

Otters did not use all parts of their home ranges equally. Similar to Melquist and Hornocker's (1983) findings, otters in this study showed preferences for some sites over others. Extended use areas were plotted for male 01 and male 03 (Fig. 8). These represent areas where the males were located a minimum of five times during the study. Note that the one extended use area of male 03 is within the area used earlier by yearling female 04.

Unlike Erlinge's (1967*b*) findings, movements within home ranges by otters in this study did not appear to follow any pattern. Sometimes otters remained at the same site for up to four consecutive days before traveling to another site. At other times they were located at a different site every day for up to five consecutive days.

SUMMARY

Travel routes of otters generally paralleled the shoreline; however, otters were occasionally observed swimming across as much as 3 km of open water. One radio-tagged adult female was located on one occasion in a burrow within 2 m of a freshwater lake.

Monitoring of a radio-tagged adult male indicated that he was chiefly nocturnal during all seasons and three all-night monitoring sessions revealed movements of 6.4, 7.0, and 4.0 km. A radio-tagged yearling male was located most often at resting sites during the daytime, but a radio-tagged adult female was observed in the water during daytime hours nearly as often as she was located at resting sites. The radio-tagged adult male traveled significantly longer distances in 24-hour periods during the fall than during the spring.

Several factors probably dictate movements by river otters: Prey abundance and availability, reproductive activity, human activity, and intrinsic factors such as exploratory and marking activities and dispersal. The combination of feeding, searching for signs left by other otters, and marking activities probably dictated movements by otters during most of the year in this study.

Home ranges were delineated for three radio-tagged otters: An adult male used an area of 20.9 km^2 with a total shoreline length of 39.9 km; a yearling male used an area of 24.8 km^2 containing a total shoreline length of 19.0 km; and an adult female used an area of 8.9 km^2 with a total shoreline length of 21.7 km. The home ranges of the radio-tagged adult and yearling males overlapped slightly. The radio-tagged adult male was periodically observed together with six other otters from June through September. These otters were occasionally observed traveling, feeding, and resting together.

Seasonal changes in home range size were determined for the radio-tagged adult male. Home range size was similar during summer, spring, and fall: Summer, 15.2 km^2; spring, 13.1 km^2; and fall, 12.6 km^2. The delineated winter use area of 4.7 km^2 was derived from only six loctions and is probably smaller than the actual area used by the adult male during this season. Radio-tagged otters did not use all parts of their home ranges equally; some sites within their home ranges were used more than others. Movements between sites did not follow any apparent pattern.

The information presented here is based on data collected from four radio-tagged otters and should be considered preliminary. As the first information addressing movements and home range sizes of coastal river otters, these results set the stage for much needed future research into this important aspect of otter ecology.

POPULATION CHARACTERISTICS

Knowledge about population sizes and trends can be of value in managing wildlife. Information of this type can be useful in establishing hunting and trapping bag limits. In coastal southeastern Alaska, where habitat alterations occur as a result of clearcut logging, comparisons between the number of river otters supported on altered and unaltered forest habitats would be valuable to timber managers and wildlife biologists in their efforts to develop appropriate land use practices.

The secretive and nocturnal habits of river otters, in combination with the difficulties associated with capturing them, make it difficult to determine population sizes and trends for this species. Standard techniques for estimating population size (Overton 1969) are often not applicable (Melquist and Hornocker 1983) and could not be used in this study. An estimate of the size of the otter population on the Cholmondeley Sound study area was made using a combination of telemetry data, visual observations of unmarked otters, and trapper harvest information.

MATERIALS AND METHODS

Population size was estimated between June and September 1981. The estimate was based primarily on information obtained from monitoring adult male 01, sightings of unmarked otters observed within the boundary of male 01's 20.9 km^2 home range (*see* Home Range Section, pg. 92), and information obtained from a local trapper concerning the total number of otters trapped and shot within male 01's home range during the 1979-80 and 1980-81 trapping seasons. Most of the information related to population size was obtained from the area used by male 01 because of its proximity to the field camp, making the amount of time observing otters much greater than elsewhere on the study area. In addition, adult male 01 was observed together with six other otters between June and September, making it possible to distinguish these seven individuals from others seen during the same time period at different locations within the area. Information obtained from the monitoring of adult female 02 and yearling male 03 and associated sightings of unmarked otters within their respective home ranges (*see* Home Range Section, pg. 92) was of limited value. This was due to my inability to differentiate among the unmarked otters which were observed. Some recounts of the same individuals probably occurred within the ranges of otters 02 and 03.

Density has been defined as the number of individuals in relation to the space in which they occur (Krebs 1972). Foraging and feeding by otters is normally concentrated near shore at depths up to about 18 m (Scheffer 1953) and use of terrestrial habitats is generally restricted to a 20 m-wide strip adjacent to the beach (*see* Habitat Use Section, pg. 26). The term density in this study was therefore used to describe the number of otters residing along a given length of shoreline. This approach was also taken by Erlinge (1968*a*), Home (1977), Melquist and Hornocker (1983), and Woolington (in prep.).

RESULTS AND DISCUSSION

POPULATION ESTIMATE

The number of river otters inhabiting Cholmondeley Sound was estimated to be between 86 and 95. This estimate was derived after first estimating the minimum number of otters believed to coexist along the 39.9 km of shoreline within the home range boundary of male 01 (*see* Home Range Section, pg. 92).

Simultaneous observations were made of unmarked otters and a group of seven, which male 01 remained a part of from June through September 1981. Three separate unmarked individuals, known to be different from the group of seven, were observed during this time period, making the total number for the area at least 10. Two additional unmarked otters were observed; however, it was uncertain whether or not they had been recorded previously as one of the other three individuals. If they were different, the count for the area would increase to a minimum of 12. R. Olson (pers. commun.) traps otters annually on the study area and reported trapping seven and shooting two otters within the home range boundary of male 01 during the combined 1979-80 and 1980-81 trapping seasons. These nine additional individuals, if added to the count of 10-12, brings the total to 19-21 otters/39.9 km of shoreline or one otter/1.9-2.1 km of shoreline. These figures are comparable to estimates made by Home (1977) and Woolington (in prep.) in other parts of southestern Alaska. Home (1977), working along a stretch of coastline in Glacier Bay, reported observing 11 otters occupying 22.66 km of shoreline, giving an estimated density of one otter/2.06 km of shoreline. Woolington (in prep.), working with otters on the north end of Baranof Island in southeastern Alaska, estimated a minimum of 18 otters/23.2 km of shoreline or one otter/1.3 km of shoreline.

Including islands, Cholmondeley Sound contains approximately 180 km of shoreline. In the absence of a better estimator, the ratio of one otter/1.9-2.1 km of shoreline was applied to this total length, resulting in a population estimate for the Cholmondeley area of 86 to 9[illegible] otters.

The inclusion of the nine otters which were killed within the home range of male 01 between 1979 and 1981 may have inflated the estimate for that area. This would be the case if the removal of the nine otters resulted in immigration of new individuals from outside the area into the vacated areas. Melquist and Hornocker (1983) observed the dispersal of a yearling female into a region where two and possibly three adult females had died two years earlier. If this occurred in this study, there would be a chance that some of the observed individuals were immigrants which would not have been present had the nine deceased otters remained on the area. However, during the course of the study, 41 separate observations of unmarked otters were made in this area. Although sightings of the same individuals undoubtedly occurred, there were also probably some otters which, although present, were never observed.

Observations of some otters were not included in the population estimate because of difficulty in identifying the otters and their respective home ranges. For example, five otters (two adults and three pups) were observed moving through the westernmost part of male 01's home range during September (*see* Home Range Section, pg. 92). Previous observations of the family group suggested that this area of mutual use represented only a small overlap between their home range and the home range of male 01 and his companions. Eleven observations of unmarked otters were made within the home range of adult female 02 and six within the home range of yearling male 03. However, in the areas used by 02 and 03, it was not possible to distinguish between unmarked otters observed for the first time and otters previously counted. Seventeen additional sightings of unmarked otters were made outside of the home ranges of the radio-tagged otters.

FACTORS INFLUENCING POPULATION SIZE

Availability of Preferred Habitat

River otters inhabiting Cholmondeley Sound rarely used clearcuts. Cholmondeley Sound contains approximately 9.6 km of shoreline along clearcuts where the clearcuts extend to the beach and are devoid of residual beach fringe timber (*see* Habitat Use Section, pg. 21). Using the ratio of one otter/1.9-2.1 km of shoreline as an estimate of the minimum number of otters occurring along the coast of Cholmondeley Sound, the loss of 9.6 km of habitat as a result of clearcut logging could be equivalent to a potential loss of approximately five otters. This could result in a reduction in the population estimate for Cholmondeley from 86-95 to 81-90 individuals. These estimates must be considered preliminary, but they may be an indicator of the impact of loss of beach fringe forests to otters.

Prey Abundance and Availability

Prey abundance and availability are probably not as limiting to otters living along the coast of southeastern Alaska as they are to otters living in inland areas. The marine system, with its abundance and diversity of vertebrate and invertebrate organisms, provides the bulk of the otters' food requirements throughout the entire year (*see* Feeding Habits Section, pg. 119). Organisms living in freshwater lakes and streams may serve to supplement otters' diets. Melquist and Hornocker (1983), in an otter study in west central Idaho, estimated the otter density to be one otter/3.7 km of waterway. This estimate, about half to a third as large as the estimates given for marine systems by Home (1977), Woolington (in prep.), and this study, may reflect seasonal (winter) shortages of prey associated with freshwater systems. Likewise, Erlinge's (1968*a*) estimate of one otter/2-3 km of lake shore and one otter/5 km of stream length for otters in southern Sweden may reflect the relatively low freshwater prey abundance and availability compared to marine systems.

Territoriality

The presence of territories, from which conspecifics are excluded, can act as a population regulating mechanism. Feces and anal pouch secretions, deposited on piles of scraped-together forest litter and twigs (mark piles), were often encountered during this study (*see* Habitat Use Section, pg. 23). These appeared to be used for social communication among otters and probably had sexual and/or territorial significance. Erlinge (1968*a*) found that otters (*L. lutra*) increased their marking activity at times of high density and decreased their marking activity as density became lower. Jenkins (1980) suggested conventional (spacing) territories and avoidance at low otter densities and temporal territoriality plus avoidance at high densities in inlet systems in northern Scotland.

Territories are often maintained in order to reduce competition for one or more limited resources. If otters in southeastern Alaska establish territories, as the presence of mark piles suggests, it may be in response to a resource which is limiting. The fact that mark piles are deposited year-round suggests that territories are not linked solely to sex-related factors.

Availability of burrow sites (*see* Burrow Characteristics, pg. 50) in Cholmondeley Sound is probably not limiting to otter population size. While walking through the forest on the study area I observed several natural cavities which, although not used by otters, appeared similar to cavities which were used. Kruuk and Hewson (1978) indicated that otters (*L. lutra*) living along the coast of Scotland had difficulties capturing prey and they felt that this reflected a limited prey resource. These authors further indicated that the even distribution of burrows along the coast was the result of territoriality triggered by limited prey. Prey may likewise be the limiting resource in Cholmondeley Sound. However, more information is needed concerning factors responsible for partitioning of otter territories before the influence of territoriality on otter population densities in southeastern Alaska can be understood.

Mortality

Man-related deaths probably account for most of the mortality of the Cholmondeley Sound otter population. Trapping and shooting usually account for 10-28 otter deaths each year (Table 22). Using the population estimate of 86-95 individuals, this calculates to an annual man-related mortality rate of 9-32%.

In addition to 12 otters killed by the local trapper during 1980-81, four otters died inadvertantly as a result of this study. Two adult female otters died of hypothermia as a result of live-trapping efforts. This occurred when inclement weather made it impossible to check traps on the study area for three consecutive days. One of these two otters was captured within the home range of adult female 02 (*see* Home Range Section, pg. 92). On one occasion an otter was believed to have been responsible for breaking a weak tie-down chain on a leg-hold trap and escaping with the trap. It is unlikely that the otter survived with the trap on its foot. Yearling female 04 was found dead in a burrow approximately one month after she was released.

River otters have few natural enemies. While swimming along the coast they are essentially safe from predators. However, during open-water crossings between adjacent land areas, they become vulnerable to killer whales which may consume an occasional otter. Yearling male 03 was last located on 18 October 1981 and had previously been observed swimming between Skin Island and Chasina Point, a distance of approximately 3.3 km (Fig. 1, pg. 6). At the time of 03's last location, a pod of 13 killer whales moved into Cholmondeley; possibly 03 was intercepted and killed by the pod during his open-water travels.

Table 22. Number of river otters shot and/or trapped in Cholmondeley Sound and on all of Prince of Wales Island, 1977-1983.

	Cholmondeley Sound			Prince of Wales Island
Season	Male	Female	Total	Total
1977-78	3	8	11	305
1978-79	10	10	20	191
1979-80	7	3	10	225
1980-81	6	6	12	140
1981-82	6	10	16	108
1982-83	11	17	28	122
1977-83	43	54	97	1,091

Home (1977) reported finding otter hair and bones in wolf scats collected in Glacier Bay, indicating the potential for predation on otters moving between marine and freshwater systems. Bears probably kill a few otters also. Rosen (1975) reported a mutually fatal encounter between a bald eagle and an otter in Newfoundland. The two had apparently killed each other fighting over a fish. It is unlikely, however, that aggressive confrontations occur very often between these two species.

Death due to natural causes is the most difficult to assess. Most natural deaths go unnoticed because they occur in remote areas. During this study, an intact skeleton of a young river otter was found within 2 m of a burrow located about 5 m inland from the beach. The otter had died in a stretched out position under the canopy of several large hemlock trees. The likelihood of predation or scavenging was ruled out since the bones were all present and in order rather than scattered about.

Parasites and disease may kill some otters; however, this was not documented in this study. Roundworms observed in scats collected on the study area may have been ingested along with prey species consumed by otters.

Reproduction

Female otters do not usually become sexually mature until two years old (Liers 1951, Hamilton and Eadie 1964), and Liers (1951) reported that his captive males could not be counted on as successful breeders until five to seven years of age. Otters in southeastern Alaska usually breed in May (Solf 1978; Woolington, in prep.; J. Noll, pers. commun.). The zygote develops to the blastocyst stage and remains dormant in the uterus until spring, a phenomenon known as delayed implantation. Litters usually consist of two or three pups (Liers 1951, Hamilton and Eadie 1964, Mowbray et al. 1979, Melquist and Hornocker 1983) which are usually born during March or April (Tabor 1974, Melquist and Hornocker 1983), or May (Woolington, in prep.). Females give birth to one litter a year. Tabor and Wight (1977) believed that female otters in Oregon bred annually. However, entire litters have been known to be resorbed (Mowbray et al. 1979).

Data are not available for computing the reproductive rate of the Cholmondeley Sound otter population. However, limited information is available from sightings of young otters and from observations made of embryos implanted in the uterus of an adult female.

Observations of two young otters were made on 11 and 12 February 1981 in the west arm of the study area (Fig. 1, pg. 6). They were recognized as being young by the "chirping" sounds they made. Adult otters do not normally include this sound in their vocabulary (G. Stenson, pers. commun.).

On 10 March 1981 an adult female was found dead from hypothermia in a leg-hold trap. A necropsy revealed three implanted embryos with a crown-rump length of approximately 20 mm, about one tenth their full-term length (Hamilton and Eadie 1964). On 28 and 29 September 1981 and on 11 October 1981, five otters (two adults with three pups) were observed swimming and feeding about 3 km east of Dora Bay (Fig. 1, pg. 6). R. Olson (pers. commun.) shot a juvenile female on 5 December

1981. It was swimming alone on the north side of Cholmondeley Sound at the time it was killed.

These observations suggest that a minimum of seven pups were, or would potentially have been, born in Cholmondeley Sound during 1981. It is highly likely that the actual annual recruitment for the Cholmondeley population is greater than seven.

SUMMARY

The size of the river otter population along the 180 km of shoreline in Cholmondeley Sound was estimated to be between 86 and 95 individuals. This estimate was obtained by first estimating the number of otters residing within the boundary of adult male 01's home range. From observations of unmarked otters in this 20.9 km^2 home range, with a total shoreline length of 39.9 km, a density of one otter/1.9-2.1 km of shoreline was estimated. This density estimate was then applied to the entire 180 km of shoreline in Cholmondeley Sound. Densities comparable to the one obtained for male 01's home range were estimated in Glacier Bay (Home 1977) and on Baranof Island (Woolington, in prep.) in southeastern Alaska.

Loss of habitat due to clearcut logging may result in a reduction in the total number of otters which an area can support. For example, using the density estimate of one otter/1.9-2.1 km of shoreline, the loss of 9.6 km of shoreline adjacent to clearcuts in the Cholmondeley Sound area may have resulted in a loss of approximately five otters from this area. Abundance of preferred microhabitat characteristics such as convex shoreline configurations and short intertidal lengths may also influence the size of the otter population which can be supported on an area.

Prey abundance and availability are probably less limiting to otters inhabiting the marine coast of southeastern Alaska than to otters living in inland areas. Burrow sites did not appear limited on this study area and are probably not limiting the size of the otter population.

Territorial behavior may play a role in regulating population densities. This potential population controlling mechanism is not well understood for river otters and deserves future attention.

Man-related deaths probably account for most of the otter mortality in Cholmondeley Sound (10-28 each year from 1977-1983). Additional otter mortality may result from interspecific conflicts with potential predators such as wolves (Home 1977), bears, or killer whales, or from rare confrontations with bald eagles (Rosen 1975). No information was collected to determine parasite or disease-related mortality.

Observations of young otters and an observation made of embryos implanted in the uterus of an adult female suggest that a minimum of seven pups were, or would have been, produced in Cholmondeley Sound during 1981.

FEEDING HABITS

Diets of river otters inhabiting freshwater lakes and streams have been described in the literature (Wilson 1954, Knudsen and Hale 1968, Modaferri and Yocom 1980, Melquist and Hornocker 1983). However, studies of feeding habits of otters living in coastal regions of North America have not been reported. Toweill (1974) discussed the diets of river otters in both coastal and inland areas of Oregon, but no separation was made between stomach contents of otters caught in coastal areas and those captured in inland locations. This study was conducted to determine principal prey species eaten by coastal river otters inhabiting Cholmondeley Sound.

MATERIALS AND METHODS

During June-August 1980 and all of 1981, 272 river otter scats were collected on the study area. Date and location of collection were recorded and each scat was identified as recent (deposited < two weeks earlier) or old (deposited between two and four weeks earlier). Recent scats were distinguished by compactness, dark color, and presence of moist particles which had not washed away or dried out. Old scats were recognized by partial breakdown as a result of weathering. Scats were oven-dried in the field camp and stored in plastic bags for later analyses.

Dried scats were weighed, broken apart, and examined using a binocular microscope. Scat weights ranged from 0.33 g to 25.62 g ($\bar{x}$ = 5.39 g; SD = 3.61). Prey remains were identified by comparison with reference specimens obtained from the University of Alaska Museum's fish and invertebrate collections. Otoliths and scales were the items most often used to identify fish remains. Otoliths that could not be identified using an otholith key (Morrow 1979) were sent to J. Fitch of San Pedro, California for identification. Reference aids by Johnson and Snook (1927), Yancey (1964), Quast and Hall (1972), and Hart (1973) were also used.

Prey items were recorded as absent or present in a scat. The number of scats containing a particular food item was expressed as a percentage of the total number of scats collected (frequency of occurrence). Any evidence of a prey species in a scat, even though more than one individual of that species might be present, was treated as a single occurrence.

In addition to determining frequency of occurrence of prey items, ocular estimates were made of the relative proportion each prey item constituted of each scat. This was subjective and required the use of broad percentage classes; >0-5%, >5-25%, >25-50%, >50-75%, >75-95%, >95-100% (Daubenmire and Daubenmire 1968). The number of otoliths of a species, the abundance of a species' scales, the number of preopercle bones from a given species, and the amount of invertebrate exoskeleton were the characters used to assign volume estimates. To calculate the proportion of the total volume of scats made up by each food item, the midpoint of each volume class was first determined for each item and the following equation was used:

$$\text{Volume (\%) of food item (x)} = \frac{\sum_{i=1}^{n} \text{Percent volume of food item (x)}}{\sum_{i=1}^{N} \text{Percent volume of all food items}}$$

n = Number of scats containing food item (x).

N = Total number of scats = 272.

In using this method of volume estimation, two assumptions were made based on the distribution of the data:

1. For all food items, a food item had the same probability of occurring in a small volume scat as it did in a large volume one.
2. For all food items, a food item could occur in the same proportion in both large and small volume scats.

Seasonal changes in otter diets were determined from the analyses of 249 otter scats for which the season of deposition was known. Seasons were assigned as: winter (Dec - Feb), spring (Mar - May), summer (June - Aug), and fall (Sept - Nov). Chi-square analyses were used to test for seasonal changes in diet.

RESULTS AND DISCUSSION

Fish was the predominant food found in otter scats, reflected both in the frequency of occurrence (96%) and the proportion of the total scat volume (86%) (Fig. 10, Table 23). Direct comparisons between frequency of occurrence and percent of total scat volume are presented to show the relationship between these two values for the six observed food items. For all items except the miscellaneous invertebrates there appears to be a close association between these values. Crabs are not included with the miscellaneous invertebrates, which consist of gastropods, pelecypods, isopods, amphipods, and stomapods. These invertebrates occurred in 30% of all scats, although contributing only about 2% to the total volume. This disparity is probably due to secondary ingestion of invertebrates by otters; the invertebrates were probably eaten first by fish, crabs, or birds that were then eaten by otters. Of 81 scats in which miscellaneous invertebrates were found, 77 contained fish remains in addition to the invertebrates, three contained crab and fish remains, and one scat, containing a single snail shell, consisted of bird feathers. With the exception of crabs, no scats containing only invertebrate remains were encountered in this study.

Small fragments of urchin exoskeletons were found in four scats and were probably ingested directly by otters while extracting the soft body parts from these invertebrates. The frequency of occurrence, as well as the total volume estimate of urchins, was probably underestimated in these results because the exoskeleton is not consumed and most of the soft body tissues are digested. The importance of abalone and chitons were also underestimated since remains from their soft tissues are

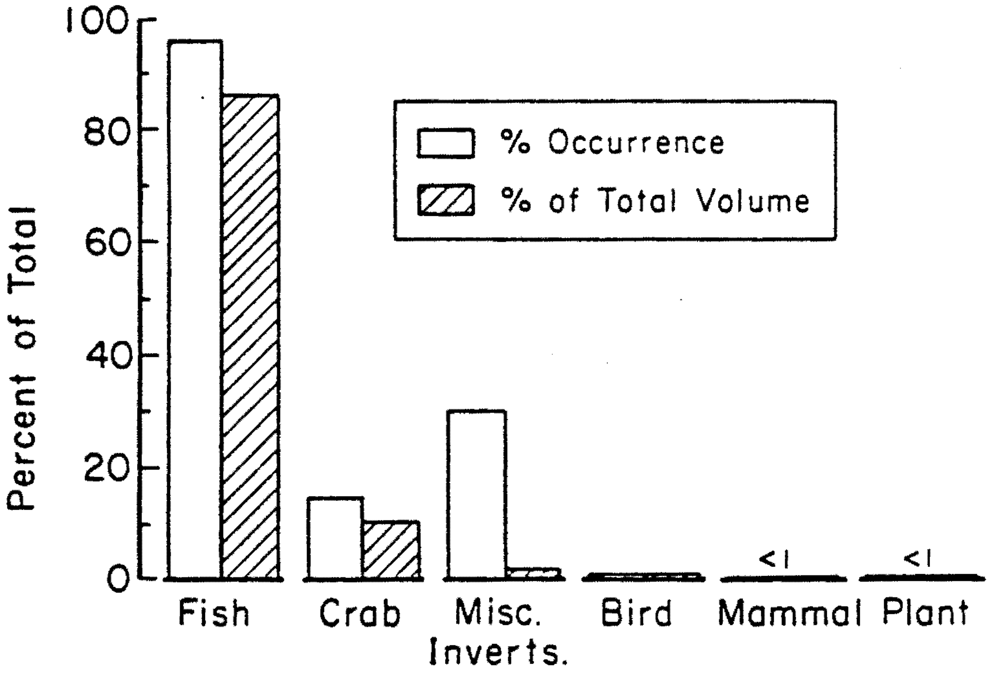

Fig. 10. Percent of otter scats containing various food items and percent of total scat volume made up of each item. Based on remains in 272 scats collected in Cholmondeley Sound, 1980-1981.

Table 23. Annual diet of river otters. Based on remains in 272 scats collected on the study area in Cholmondeley Sound, 1980-1981.

Food item	Number of scats in which each food item occurred	Frequency of occurrence (%)	Proportion of total scat volume made up by each food item (%)
FISH	261	96	86
Ammodytidae			
Ammodytes hexapterus (Pacific sand lance)	5	2	<1
Clupeidae			
Clupea harengus pallasi (Pacific herring)	3	1	<1
Cottidae	177	65	49
Artedius spp.	23	8	5
Enophrys bison (Buffalo sculpin)	1	<1	<1
Hemilepidotus spp. (Irish Lords)	80	29	20
Icelus spatulata (Spatulate sculpin)	1	<1	<1
Leptocottus armatus (Pacific staghorn sculpin)	4	1	<1
Myoxocephalus scorpius (Shorthorn sculpin)	1	<1	<1
Radulinus asprellus (Slim sculpin)	1	<1	<1
Rhamphocottus richardsoni (Grunt sculpin)	2	<1	<1
Unidentified Cottid	79	29	21
Embiotocidae			
Unidentified Embiotocid (Surfperches)	1	<1	<1
Gadidae	7	3	1
Microgadus proximus (Pacific tomcod)	3	1	<1
Theragra chalcogramma (Walleye pollock)	3	1	<1
Unidentified Gadid	1	<1	<1
Hexagrammidae	38	14	7
Hexagrammos octogrammus (Masked greenling)	1	<1	<1
Hexagrammos stelleri (Whitespotted greenling)	2	<1	<1
Ophiodon elongatus (Lingcod)	2	<1	<1
Unidentified Hexagrammid	35	13	7
Pholidae/Stichaeidae			
Unidentified Pholid or Stichaeid (Gunnels/Pricklebacks)	11	4	2

Table 23. Annual diet of river otters (cont.)

Food Item	Number of scats in which each food item occurred	Frequency of occurrence (%)	Proportion of total scat volume made up by each food item (%)
Pleuronectidae/Bothidae	11	4	2
Citharichthys spp. (Sanddabs)	2	<1	<1
Soles	6	2	2
Unidentified Pleuronectid/Bothid	3	1	<1
Salmonidae			
Unidentified Salmonid	12	4	4
Scorpaenidae			
Sebastes spp. (Rockfish)	45	17	12
Unidentified fish	25	9	5
CRABS	42	15	10
Cancer gracilus	1	<1	<1
Cancer magister (Dungeness)	15	6	5
Cancer oregonensis	1	<1	<1
Cancer productus (Red)	1	<1	<1
Cancer spp.	2	<1	<1
Telmessus cheirogonus (Horse)	10	4	3
Placetron wosnessenskii	1	<1	<1
Hapalogaster spp.	1	<1	<1
Unidentified crab	11	4	1
INVERTEBRATES (other than crabs)	81	30	2
Tonicella lineata (Lined chiton)	7	3	<1
Pelecypoda (clams)	25	9	<1
Crustacea (amphipods, isopods, decapods)	27	10	<1
Acmaea spp. (limpets)	16	6	<1
Gastropoda (snails)	30	11	<1
Strongylocentrotus spp. (urchins)	4	1	<1
BIRDS			
Unidentified bird	3	1	1
MAMMALS			
Odocoileus hemionus sitkensis (black-tailed deer)	1	<1	<1
PLANT MATERIAL	1	<1	<1

unidentifiable in otter scats. Intact abalone shells and chiton plates and girdles were commonly found at otter feeding sites.

Starfish legs were found on four occasions at otter use areas and, on one occasion, seven otters, feeding together, were observed eating starfish on rocks adjacent to salt water. Since remains of the calcareous skeletal structures found in starfish should be recognizable in scats, their absence from this sample probably reflects the infrequent use of this prey item.

Birds usually make up very little of the diet of otters (Sheldon and Toll 1964, Toweill 1974, Modafferi and Yocom 1980). However, Gilbert and Nancekivell (1982) found a high frequency of avian remains in otter scats which they felt probably reflected high utilization of breeding and molting waterfowl. Quinlan (1979) observed storm-petrel (*Oceanodroma* spp.) remains scattered around otter burrows on Wooded Islands in the Gulf of Alaska and found that 166 of 193 (86%) of the otter scats she collected in the summer of 1977 contained storm-petrel feathers. Otter predation on these birds was heaviest during late May and early June. It appears that when birds are readily accessible, they may be a major part of the diets of otters (Hayward et al. 1975).

In this study, birds were found in three scats. Although identification of the bird species was not possible, they were probably alcids; possibly common murres (*Uria aalge*) or murrelets (*Brachyramphys* spp.).

Mammals are generally unimportant as food for North American otters (Wilson 1954, Knudsen and Hale 1968, Melquist and Hornocker 1983) and European otters (*L. lutra*) (Erlinge 1967*b*, Webb 1975). In this study, a single scat contained deer hair. The scat was collected in May and it is possible that an otter found a deer carcass and fed on it. Otter hair was observed in a few scats, probably the result of grooming (Greer 1955, Melquist and Hornocker 1983).

Mink (*Mustela vison*) and beaver (*Castor canadensis*) occur on the study area; however, no indication of otters feeding on either species was found. Novikov (1962) asserts that in the USSR European otters vigorously hunt mink. In this study, otter and mink burrows, as well as general use areas of both species, were often located within 5 to 10 m of each other, yet no evidence was found to suggest aggressive encounters between these mustelids.

Plant material, believed to be grass, was found in one scat which was collected in July. This nominal occurrence of plant matter is comparable to findings of other researchers (Lagler and Ostenson 1942, Knudsen and Hale 1968) and is indicative of the infrequent use of vegetative material by river otters.

Eleven families of fish were identified in otter scats (Table 23, Fig. 11). Cottids (sculpins) were the most commonly eaten fish. Ryder (1955) indicated that the occurrence of a species of fish in the diets of otters is influenced by the abundance and the swimming ability of the fish species. Most cottid species are found in shallow water and may be abundant in the intertidal zone (Hart 1973). The abundance and species diversity of cottids living along the coast of this study area, in combination with their relative ease of capture, probably account for their high frequency of occurrence in the scats collected.

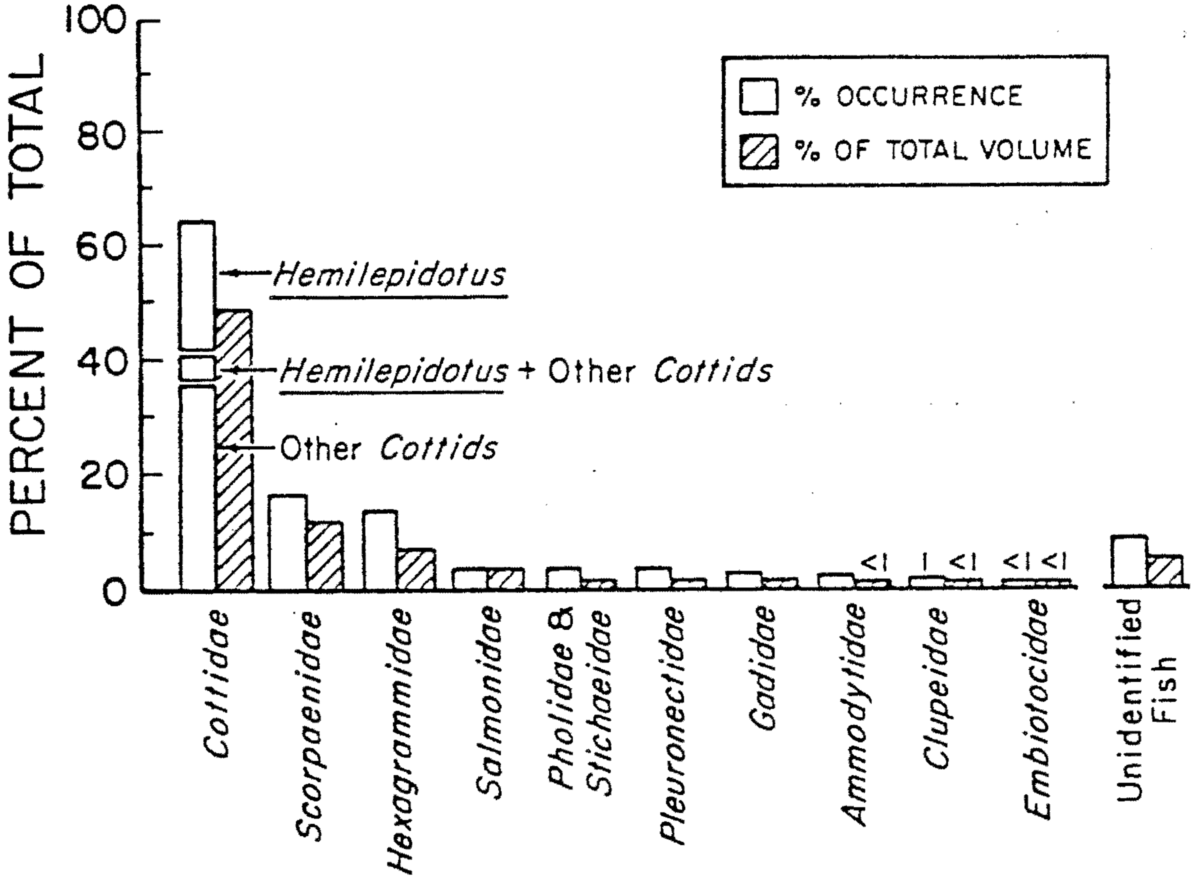

Fig. 11. Percent of otter scats containing identifiable fish families and percent of total scat volume made up by each family. Based on remains in 272 scats collected in Cholmondeley Sound, 1980–1981.

Eight genera of cottids were identified including Irish lords (*Hemilepidotus* spp.) which occurred in 29% of all scats and made up 20% of the total volume estimate. Irish lords were easily identified in scats by the presence of their cycloid scales positioned on raised papillae (Hart 1973). Red (*H. hemilepidotus*), brown (*H. spinosus*), and yellow (*H. jordani*) Irish lords could often be identified to species using otoliths found in otter scats.

Four species of the genus *Artedius* occur on the study area and although all are probably eaten by otters, identification to species was not possible. Collectively, species of *Artedius* occurred in 29% of the scats and made up 5% of the total volume estimate. The remaining seven species of cottids identified were found in only 4% of the scats; however, this value is probably low since some of the unidentified cottids were undoubtedly members of these species.

Three species of hexagrammids were observed in scats; masked greenling (*Hexagrammos octogrammos*), whitespotted greenling (*H. stelleri*), and lingcod (*Ophiodon elongatus*). Although remains of these three species were identified in only five scats, their presence in at least a few of the 35 scats containing unidentified hexagrammids is probable. On one occasion, a lingcod carcass, measuring approximately 50 cm from nose to fork of tail, was found at an otter use area approximately 5 m inland from the beach, indicating use by otters of relatively large fish.

Salmonids occurred in 4% of the scats and made up 4% of the total volume estimate. All 12 scats containing salmonid remains were collected during September and October when pink and chum salmon were spawning in streams on the study area. In late September, two female pink salmon carcasses were found lying on a grass-covered area next to a large stream. Each of the two fish, which had been fed on by otters, had one side partially eaten away along with the viscera. Undigested salmon roe was observed in one otter scat from this area and may have come from the two carcasses.

In addition to salmon, carcasses of rockfish, lingcod, flounder, sculpin, and walleye pollock (*Theragra chalcogramma*) were found around otter use sites on the study area. No fish carcasses with a length of <30 cm were found during this study, suggesting that smaller fish are normally eaten completely whereas parts of larger fish, such as the skull and vertebral bones, may be left uneaten (Erlinge 1968*b*).

Pholids (gunnels) and stichaeids (pricklebacks) were combined into one group during scat analyses because of the difficulty in distinguishing between these two families. Likewise, the pleuronectids and bothids (flatfishes) were combined.

Occurrence of cottids and scorpaenids in otter scats changed seasonally (Fig. 12). Cottids were the most important group during all seasons. A chi-square analysis indicated a significant change in the seasonal use of this group as a result of the changes observed for the *Hemilepidotus* spp. (Table 24). No significant seasonal changes were noted for the hexagrammids. Scorpaenids showed significant changes from winter to spring, when use of cottids by otters decreased and use of scorpaenids increased. Inversely, as cottids increased from spring through the fall, scorpaenids decreased (Table 24).

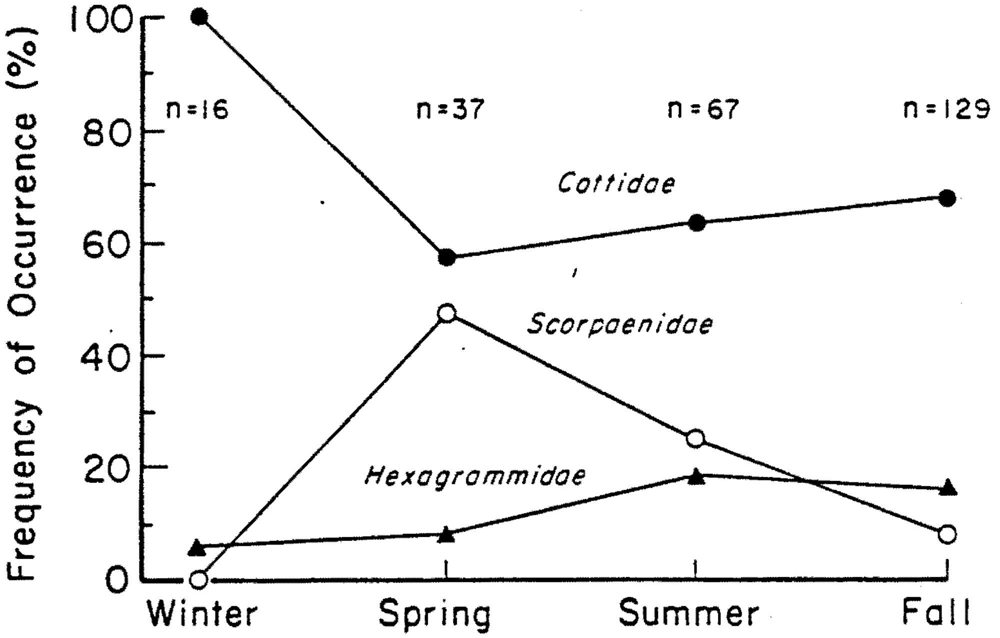

Fig. 12. Seasonal changes in otter use of fish families most often encountered in scats. Based on remains in scats collected in Cholmondeley Sound, 1980-1981.

Table 24. Chi-square results of seasonal changes in the use of important fish families eaten by river otters in Cholmondeley Sound, 1980-1981.

FOOD ITEM	WINTER		SPRING		SUMMER		FALL		χ^2	df	
	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected			
Hexagrammidae	1	2.45	3	5.35	12	9.78	21	19.42	2.98	3	
Scorpaenidae	0	2.84	15	6.22	17	11.37	11	22.57	29.12	3	**
Cottidae	16	10.90	21	23.86	42	43.64	86	86.59	8.78	3	*
Hemilepidotus	14	5.09	6	11.14	17	20.36	40	40.40	27.16	3	**
Other Cottids	3	6.88	16	15.04	27	27.50	58	54.58	4.34	3	
Number of Scats	16		37		67		129				

* $0.025 < P < 0.05$ ** $P < 0.001$

Red Irish lords spawn during March and April in shallow water (Hart 1973). Some scorpaenids also move into shallow water during spring (Gunderson 1972). It would seem that as a function of their increased abundance, the occurrence of Irish lords in otter scats would have increased during the spring. There are three explanations as to why this did not occur: Otters preferred scorpaenids over Irish lords, otters were able to capture more scorpaenids than Irish lords, or scorpaenids were more abundant than Irish lords.

The frequency of occurrence of fish, crabs, and birds changed seasonally (Fig. 13). The importance of fish throughout all seasons is reflected by their occurrence in 100% of the winter scats, 95% of the spring and summer scats, and 98% of the fall scats. There is a possible compensatory relationship between fish and crab in the diet of otters; as the occurrence of fish decreased, crab occurrence increased and conversely, as fish increased crab decreased. Seasonal changes in the occurrence of crab and fish in otter scats were not significant ($\chi^2 = 3.1$, 3 df, $0.25 < P < 0.5$). The increase in occurrence of crabs during spring and summer may be due to increased availability; several species of crabs move into shallow water in the spring and summer where they breed (Hatler 1976).

SUMMARY

Fish was the most important food eaten by otters. Cottids (sculpins) were the most important group of fish during all seasons despite a 43% decrease in the occurrence of this group from winter to spring. The decrease in cottids occurred together with a 47% increase

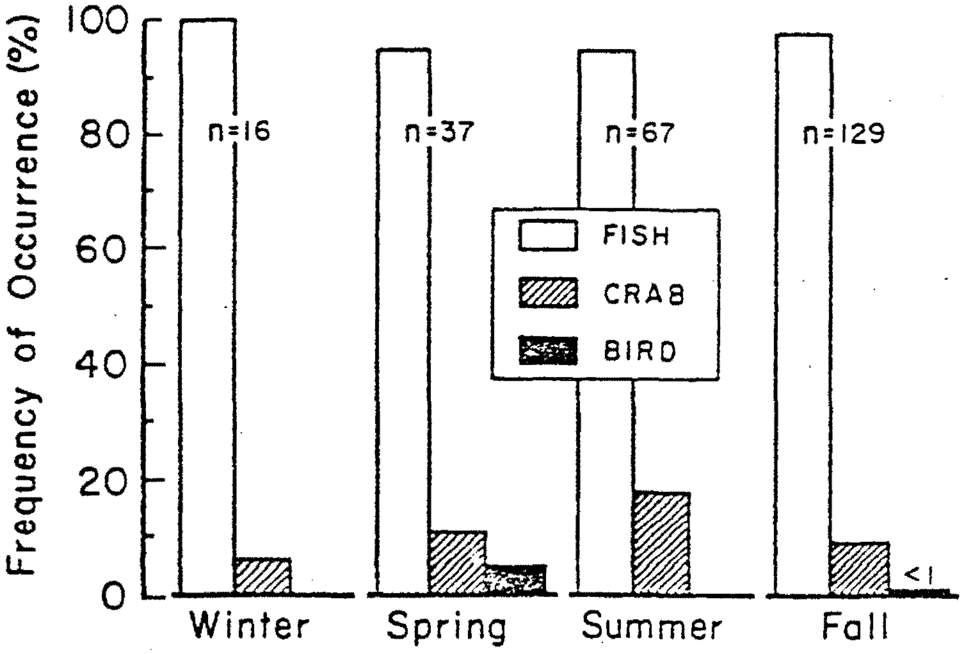

Fig. 13. Seasonal changes in otter use of fish, crabs, and birds. Based on remains in scats collected in Cholmondeley Sound, 1980-1981.

in the occurrence of scorpaenids (rockfish), the second most common group of fish eaten, and probably reflects seasonal changes in the abundance of these two families. Hexagrammids (greenlings) were the third most commonly occurring family of fish and remained relatively constant during all seasons. Remains from salmonids (salmon) were only found in scats collected in the fall and reflect use of spawning salmon during this season.

Crabs were relatively unimportant in otter diets during all seasons. Slight spring and summer increases in the occurrence of crab remains in otter scats probably reflect movement of crabs from deep to shallow water during these seasons, thereby making them more available to otters.

Bird remains were found in only three scats, suggesting that they offer little more than variety to the diet. The occurrence of deer hair in one scat probably reflects opportunistic feeding on a carcass. Miscellaneous invertebrates occurred in scats but were apparently consumed first by either fish, crabs, or birds which were in turn consumed by otters.

CONCLUSIONS

1. River otters avoided clearcut habitat. The following forest habitat types were used in proportion to their availability: Old growth high volume, old growth low volume, second growth, residual beach fringe, and islands.
2. River otter use of terrestrial habitat was usually restricted to a <20 m fringe of timber adjacent to marine beaches. Only one radio-location was made at a burrow near a freshwater lake.
3. River otters preferred habitats adjacent to convex (point) shorelines with short intertidal lengths consisting predominantly of bedrock substrate. Otter signs were associated more often than expected with microhabitats having relatively large (>51 cm) trees and/or snags, >50% canopy closure, and >0-5% *Rubus* cover.
4. One hundred forty river otter burrows were characterized. Burrows were located within 0.9-22.9 m of beaches ($\bar{x}$ = 5.4 m). Burrows were associated with areas having 0-5% *Rubus* cover and >25% canopy closure. Cavities under snags were used as burrows more often than any other structures. Mean dbh of all trees and snags associated with burrows was 85 cm (33.5 in). Burrow density was highest in old growth low volume habitat and decreased progressively in second growth, island, residual beach fringe, and old growth high volume habitats, respectively. Only two burrows were found in clearcut habitat. Mean distance between burrows in all habitats was 125.7 m. Burrow sites did not appear limited in old growth forests.

5. Travel routes of otters generally paralleled the coastline. Occasional observations were made of radio-tagged otters swimming between land areas separated by as much as 3 km. Feeding, exploring, and marking appeared to exert the greatest influence on otter movements.
6. A radio-tagged adult male otter was chiefly nocturnal during all seasons and nighttime movements of 6.4, 7.0, and 4.0 km were observed. A radio-tagged yearling male was located most often at resting sites during the daytime; a radio-tagged adult female was observed in the water during daytime hours nearly as often as she was located at resting sites.
7. A radio-tagged adult male was periodically observed traveling, feeding, and resting with six other adult otters from June through September 1981.
8. Home ranges of otters overlapped one another. Areas used were 20.9 km^2 with 39.9 km of shoreline by a radio-tagged adult male, 24.8 km^2 with 19.0 km of shoreline by a radio-tagged yearling male, and 8.9 km^2 with 21.7 km of shoreline by a radio-tagged adult female. Radio-tagged otters used some sites within their home ranges more than others. Movements between sites did not follow any apparent patterns.
9. The river otter population estimate in Cholmondeley Sound was 86-95 in 1981. Population density was estimated as one otter/1.9-2.1 km of shoreline.
10. Trapping and/or shooting accounted for 10-28 otter deaths annually on the study area from 1977-1983.

11. Fish were the most important prey of otters during each season, occurring in 95-100% of the 272 analyzed scats. Cottids, scorpaenids, and hexagrammids were the most important families of fish, occuring in 65%, 17%, and 14% of the scats, respectively. Crab occurred in 15% of the scats, bird feathers in three scats, plant material in one scat, and one scat contained deer hair.

RECOMMENDATIONS

1. River otters use residual beach fringe habitat but avoid clearcuts extending to the beach. I recommend retaining a fringe of timber $\geq$ 60 m wide adjacent to beaches during logging. This would ensure a sufficiently wide strip of timber for otter use even with some blow-down of retained trees.
2. Where beach fringe timber is to be logged, I recommend that at least old growth habitat adjacent to convex shorelines be retained because of otter selection for these areas.

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Appendix A. Daily maximum, daily minimum, and monthly temperature (C) averages, 1981, and daily maximum, 1941-1970, at Annette, Alaska, located 35 km east of Cholmondeley Sound (55°02'N, 131°34'W). Recorded by the U.S. Department of Commerce Weather Bureau.

Month	Avg. daily maximum		Avg. daily minimum		Monthly avg.	
	1981	1941-70	1981	1941-70	1981	1941-70
Jan	10.0	3.3	5.0	-1.7	7.5	0.8
Feb	6.7	5.3	1.7	-0.1	4.2	2.6
Mar	8.9	6.5	2.9	0.4	5.9	3.5
Apr	8.5	9.3	3.0	2.6	5.8	6.0
May	14.5	13.4	7.9	5.9	11.2	9.7
Jun	14.5	16.1	8.8	8.9	11.7	12.5
Jul	19.3	17.8	11.9	10.9	15.6	14.3
Aug	19.0	18.1	12.3	11.0	15.7	14.6
Sep	14.8	15.4	9.7	8.9	12.3	12.2
Oct	11.0	10.9	5.4	5.6	8.2	8.3
Nov	8.4	6.8	3.9	1.9	6.2	4.4
Dec	4.5	4.5	0.1	-0.2	2.3	2.2

Appendix B. Total monthly precipitation (cm), 1981, and average monthly precipitation, 1941-1970, at Annette, Alaska, located 35 km east of Cholmondeley Sound (55°02'N, 131°34'W). Recorded by the U.S. Department of Commerce Weather Bureau.

Month	1981	1941-70 ($\bar{x}$)
Jan	25.93	26.47
Feb	16.28	23.54
Mar	26.85	23.24
Apr	26.24	22.28
May	11.91	15.75
Jun	13.49	12.83
Jul	5.56	13.77
Aug	18.57	18.16
Sep	33.45	25.42
Oct	20.95	45.34
Nov	42.19	32.69
Dec	23.52	30.84
Total	264.94	290.33

Appendix C. Wind information from Annette, Alaska, located 35 km east of Cholmondeley Sound (55°02'N, 131°34'W). Recorded by the U. S. Department of Commerce Weather Bureau.

Month	Mean speed (km/hr)[a]	Prevailing direction[b]	Fastest speed (km/hr)[c]	Direction[c]
Jan	19.4	ESE	93	SSE
Feb	19.5	SE	80	SSE
Mar	17.6	SE	77	SSE
Apr	18.1	SSE	96	SSE
May	15.0	SSE	70	SSE
Jun	14.4	SSE	70	SSE
Jul	13.0	SSE	56	SSE
Aug	13.3	SSE	64	SSE
Sep	14.9	SE	82	SE
Oct	19.2	SE	88	SSE
Nov	19.8	ESE	82	SSE
Dec	20.3	ESE	93	SSE
Means	17.0	SSE	79	SSE

[a] Based on records from 1949-1976, 1980-1981.
[b] Based on records from 1965-1981.
[c] Based on records from 1949-1979.

Appendix D. Mean shrub and canopy cover (%), mean number of stems (trees or snags), and mean dbh (cm) on circular plots established on perpendicular transects in Cholmondeley Sound, 1980-81. Plots 1 were centered 3.6 m from the beach; plots 2, 10.7 m from the beach; and plots 3, 17.9 m from the beach.

Habitat type	Plot no.	N	Mean shrub cover *Vaccinium*	*Menziesia*	Salal	*Rubus*	*Oplopanax*	Canopy closure	Mean no. stems Hemlock	Cedar	Spruce	Alder	Snag	Total	Mean dbh Hemlock	Cedar	Spruce	Alder	Snag	Total
Old growth high volume	1	42	35	12	5	2	4	34	4.4	1.0	1.1	0.8	0.9	8.2	19.0	18.8	12.2	1.3	30.0	16.2
	2	42	42	9	8	3	5	24	3.8	0.4	0.4	0.1	0.6	5.3	23.4	18.0	5.6	1.3	23.4	14.2
	3	42	32	10	5	8	4	30	4.5	0.3	0.7	0.1	0.8	6.4	20.3	17.3	4.6	0.5	30.5	14.7
Old growth low volume	1	38	37	13	44	4	2	33	4.5	1.7	0.7	1.8	1.3	10.0	17.3	35.0	9.6	2.0	29.2	18.5
	2	38	40	13	43	3	2	35	4.6	1.1	0.3	0.4	1.1	7.5	11.2	17.0	1.5	0.8	35.3	13.2
	3	38	34	9	41	3	2	38	4.5	1.5	0.3	0.4	1.1	7.8	19.0	17.0	4.8	0.5	33.5	15.0
Second growth	1	32	28	24	8	6	2	40	5.1	6.8	2.2	1.5	2.4	18.0	13.5	17.5	11.7	5.8	24.9	14.7
	2	32	24	13	10	6	2	41	5.1	5.8	1.7	0.3	2.3	15.2	14.0	6.1	15.7	2.3	28.9	13.5
	3	32	17	7	8	5	2	43	5.3	4.2	1.3	0.5	3.6	14.9	15.2	6.6	15.0	1.8	38.9	15.5
Clearcut	1	28	25	11	3	27	7	10	2.8	1.0	2.1	0.8	0.5	7.2	6.1	2.0	3.3	0.5	27.9	7.9
	2	28	24	11	2	36	5	7	4.7	0.5	1.1	0.4	0.5	7.2	4.6	2.3	1.0	0.2	32.0	8.1
	3	28	16	5	3	47	6	9	4.2	0.9	1.6	0.6	0.2	7.5	5.3	1.8	2.5	0.8	9.4	4.1
Residual beach fringe	1	33	29	15	10	10	5	26	5.8	0.5	1.1	1.1	0.9	9.4	16.0	11.4	11.2	0.5	44.2	17.0
	2	33	34	13	9	11	2	24	4.5	0.2	0.5	0.2	0.8	6.2	12.9	7.9	3.0	0.2	42.7	13.2
	3	33	34	11	5	17	4	19	4.5	0.1	1.1	0.0	0.8	6.5	11.2	10.2	5.1	0.2	36.8	12.7

Appendix E. Distances (km) between consecutive-day locations of adult male 01 and yearling male 03, 1981. Distances were recorded as the straight line measurements between consecutive-day locations.

Individual	Date	Season	Distance
01	7-8 April	Spring	4.0
01	1-2 May	Spring	1.2
01	2-3 May	Spring	3.2
01	3-4 May	Spring	0.8[a]
01	4-5 May	Spring	0.0
01	5-6 May	Spring	0.4
01	6-7 May	Spring	3.6
01	7-8 May	Spring	3.6
01	8-9 May	Spring	1.6
01	9-10 May	Spring	0.0
01	10-11 May	Spring	1.6
01	11-12 May	Spring	1.6
01	12-13 May	Spring	0.4
01	13-14 May	Spring	0.8
01	14-15 May	Spring	0.0
01	15-16 May	Spring	2.4
01	16-17 May	Spring	0.4
01	17-18 May	Spring	1.3
01	18-19 May	Spring	0.4[b]
01	19-20 May	Spring	0.4
01	20-21 May	Spring	0.0
01	21-22 May	Spring	1.6
01	22-23 May	Spring	0.4
01	23-24 May	Spring	0.0
01	24-25 May	Spring	0.0
01	25-26 May	Spring	0.0
01	26-27 May	Spring	0.1
01	27-28 May	Spring	0.1
01	12-13 June	Summer	3.2
01	15-16 June	Summer	1.0
01	16-17 June	Summer	1.6
01	17-18 June	Summer	1.3[c]
01	18-19 June	Summer	2.9
01	19-20 June	Summer	0.0
01	20-21 June	Summer	2.4
01	21-22 June	Summer	2.2
01	22-23 June	Summer	2.4
01	23-24 June	Summer	2.2

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[a] Actual all-night observation distance was 6.4 km.

[b] Actual all-night observation distance was 7.0 km.

[c] Actual all-night observation distance was 4.0 km.

Appendix E. Distances (km) between consecutive-day locations of adult male 01 and yearling male 03 (cont.).

Individual	Date	Season	Distance
01	24-25 June	Summer	0.0
01	25-26 June	Summer	2.8
01	26-27 June	Summer	2.8
01	27-28 June	Summer	0.0
01	28-29 June	Summer	0.0
01	29-30 June	Summer	2.4
01	30 June-1 July	Summer	0.8
01	3-4 July	Summer	0.0
01	4-5 July	Summer	0.0
01	5-6 July	Summer	0.0
01	8-9 July	Summer	3.4
01	9-10 July	Summer	2.4
01	10-11 July	Summer	2.4
01	30-31 July	Summer	1.6
01	2-3 Aug	Summer	0.0
01	29-30 Aug	Summer	1.6
01	30-31 Aug	Summer	2.4
01	31 Aug-1 Sept	Fall	0.0
01	1-2 Sept	Fall	3.2
01	2-3 Sept	Fall	1.6
01	5-6 Sept	Fall	4.4
01	6-7 Sept	Fall	1.2
01	7-8 Sept	Fall	1.8
01	8-9 Sept	Fall	0.2
01	9-10 Sept	Fall	1.6
01	10-11 Sept	Fall	1.6
01	11-12 Sept	Fall	1.6
01	12-13 Sept	Fall	3.2
01	20-21 Sept	Fall	3.4
01	21-22 Sept	Fall	3.2
01	22-23 Sept	Fall	0.0
01	23-24 Sept	Fall	0.0
01	24-25 Sept	Fall	5.1
01	25-26 Sept	Fall	4.4
01	26-27 Sept	Fall	1.2
01	27-28 Sept	Fall	2.8
01	28-29 Sept	Fall	1.6
01	29-30 Sept	Fall	1.6
01	30 Sept-1 Oct	Fall	2.0
01	1-2 Oct	Fall	3.2
01	2-3 Oct	Fall	1.3
01	3-4 Oct	Fall	1.6
01	4-5 Oct	Fall	3.6
01	5-6 Oct	Fall	3.6
01	6-7 Oct	Fall	3.2

Appendix E. Distances (km) between consecutive-day locations of adult male 01 and yearling male 03 (cont.).

Individual	Date	Season	Distance
01	7-8 Oct	Fall	3.2
01	10-11 Oct	Fall	2.0
01	11-12 Oct	Fall	2.0
01	14-15 Oct	Fall	2.0
01	15-16 Oct	Fall	2.0
01	16-17 Oct	Fall	1.6
01	17-18 Oct	Fall	1.6
01	18-19 Oct	Fall	0.0
01	19-20 Oct	Fall	4.8
01	20-21 Oct	Fall	2.8
01	23-24 Oct	Fall	2.0
01	27-28 Oct	Fall	2.0
01	28-29 Oct	Fall	0.4
01	31 Oct-1 Nov	Fall	1.8
01	14-15 Nov	Fall	0.8
01	17-18 Nov	Fall	0.8
01	18-19 Nov	Fall	3.0
01	19-20 Nov	Fall	0.8
01	20-21 Nov	Fall	0.0
01	21-22 Nov	Fall	3.2
01	22-23 Nov	Fall	1.6
01	26-27 Nov	Fall	3.2
03	3-4 July	Summer	0.4
03	4-5 July	Summer	0.4
03	5-6 July	Summer	0.4
03	6-7 July	Summer	0.4
03	7-8 July	Summer	1.6
03	9-10 Sept	Fall	1.6
03	10-11 Sept	Fall	4.6
03	11-12 Sept	Fall	0.0
03	12-13 Sept	Fall	0.0
03	25-26 Sept	Fall	0.5
03	26-27 Sept	Fall	4.6
03	1-2 Oct	Fall	4.6
03	4-5 Oct	Fall	0.5
03	5-6 Oct	Fall	4.5
03	6-7 Oct	Fall	3.7
03	7-8 Oct	Fall	3.7

Appendix F. Otter sightings made on the Cholmondeley Sound study area, 1981.

Date	Time	No. of otters	Date	Time	No. of otters
12 Feb	1430	1	20 May	1945	2
21 Feb	1130	2	21 May	----	2
23 Feb	1600	1	21 May	1015	1
27 Feb	1430	1	26 May	0855	1
28 Feb	1030	1	4 Jun	0909	1
28 Feb	1400	1	15 Jun	1900	7
29 Mar	1645	2	16 Jun	2114	7
30 Mar	1815	2	18 Jun	2145	7
31 Mar	1135	1	20 Jun	2155	7
4 Apr	0728	1	21 Jun	0705	1
5 Apr	1615	1	21 Jun	1345	1
6 Apr	0708	2	21 Jun	2115	7
7 Apr	1945	2	24 Jun	2205	7
18 Apr	0700	1	29 Jun	0610	1
30 Apr	1430	1	30 Jun	0735	7
1 May	1505	1	1 Jul	0700	2
1 May	1900	1	1 Jul	0740	1
1 May	1930	2	1 Jul	0820	2
2 May	2028	1	3 Jul	0908	1
3 May	0850	1	10 Jul	2120	7
3 May	0900	1	3 Aug	1140	1
3 May	0930	1	7 Aug	1435	1
3 May	2100	1	4 Sep	1750	2
5 May	1630	1	8 Sep	0945	1
6 May	2130	1	10 Sep	0900	2
6 May	2145	1	28 Sep	1100	5
7 May	1035	1	29 Sep	0900	5
7 May	2125	1	11 Oct	1345	5
14 May	1630	1	16 Oct	1005	1
15 May	2205	1	26 Nov	1135	2
18 May	0950	1	2 Dec	1500	1
18 May	2208	1	3 Dec	1110	1
19 May	0455	1	5 Dec	----	2
19 May	1800	1	6 Dec	1300	2
20 May	1345	1	6 Dec	1630	4
			7 Dec	----	2

Appendix G. Locations of otters at the time sighted on the Cholmondeley Sound Study area, 1981.

Spotted in water, hauled out into woods:	13
Spotted on beach, ran into woods:	15
Spotted in woods:	3
Spotted in water, remained in water:	15
Spotted in woods, entered water:	6
Spotted in water, lost sight of:	7
Spotted in water, hauled out, returned to water:	6
Spotted on land, entered water, hauled out into woods:	6
Total number spotted in water:	41 = 58%
Total number spotted on land:	30 = 42%